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THE SCIENTIFIC MONTHLY

JUNE 1946

THE BIOLOGICAL BASIS OF IMAGINATION*

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A SATISFACTORY interpretation of imaginative phenomena in terms of neural mechanisms may be presented by some fortunate author at a future time. But even now there is still much of substance to be said. Knowledge normally grows by such progressive steps as clarifying and isolating a problem, identifying the variables relevant to it, and following their correlations. Only later, often much later, does the nature of the basic entities begin to become manifest and does it become possible to grapple with them.

In the field of heredity, for example, Mendel isolated the problem in terms of simple characters and followed their behavior during inheritance. These results suggested separable inherited units, which remained as hypothetical for half a century as were the atoms of Democritus for nearly two millenia. Then chromosomes were seen; in another half-century the genes became visible; and studies are now proceeding in terms of the chemical properties of specific substances. In dealing with imagination it will be profitable similarly to examine its common meaning, to consider how psychological study has defined and measured relevant mental abilities, to note the relation of local brain damage to these abilities, and to develop the relation of these psychological phenomena to neural mechanisms.

* Based on a lecture in the series "Mathematics and the Imagination" in the Winter of 1945 at The University of Chicago.

WHAT IS IMAGINATION?

Imagination is more than bringing images into consciousness; that is imagery or at most hallucination. Imagination, creative imagination, is an action of the mind that produces a new idea or insight. "Out of chaos the imagination frames a thing of beauty" (Lowes's *The Road to Xanadu*) or of truth. The thing comes unheralded, as a flash, full-formed. We have all had this experience, and famous or important cases abound.

Kekule solved the chemical problem of the benzene molecule, a ring rather than a chain of carbon atoms, when in a fatigue- (or alcohol-) engendered daydream he saw a snake swallow its tail. Michelson's "intuition" gave him the equation for some complicated tidal phenomena, and when an expert mathematician reported a different result from his calculations, Michelson sent him away to find, as he did, an error.

Otto Loewi, recently awarded the Nobel prize for proving that active chemicals are involved in the action of nerves, once told me the story of his discovery. His experiments on the control of a beating frog heart were giving puzzling results.

He worried over these, slept fitfully and, lying wakeful one night, saw a wild possibility and the experiment which would test it. He scribbled some notes and slept peacefully till morning. The next day was agony—he could not read the scrawl nor recall the solution, though remembering that he had had it. That night was even worse until at three in the morning lightning flashed again. He took no chances this time but went to the laboratory at once and started his experiment.

Others have left brief or searching records of their experiences with ideas. Darwin tells us, in a bit of autobiography, of the resolution of an amorphous mass of facts into a crystallized hypothesis as to the origin of species: "I can remember the very spot in the road, whilst in my carriage, when to my joy the solution occurred to me." And Goethe relates how his mind, supersaturated with still unorganized material, responded to the shocking news of a friend's suicide. "At that instant the plan of 'Werther' was found; the whole shot together from all directions, and became a solid mass, as water in a vase, which is just at the freezing point, is changed by the slightest concussion into ice." Hamilton tells that his famous equations . . .

> started into life, or light, full-grown, on the 16th of October, 1843, as I was walking with Lady Hamilton to Dublin, and came up to Brougham Bridge . . . the fundamental equations . . . exactly such as I have used them ever since . . . I felt a problem to have been at that moment solved, an intellectual want relieved, which had haunted me for at least fifteen years before.

Coleridge composed "The Ancient Mariner" in four months, after years of brooding on a mass of travel lore and related material; and his own statement on the manner in which "Kubla Khan" gushed forth is worth another repetition:

> In consequence of a slight indisposition, an anodyne [morphine] had been prescribed, from the effects of which [the author] fell asleep in his chair at the moment that he was reading the following sentence, or words of the same substance, in "Purchas's Pilgrimage": "Here the Khan Kubla commanded a palace to be built, and a stately garden thereunto. And thus ten miles of fertile ground were inclosed with a wall." The Author continued for about three hours in a profound sleep, at least of the external senses, during which time he has the most vivid confidence, that he could not have composed less than from two to three hundred lines; if that indeed can be called composition in which all the images rose up before him as *things*, with a parallel production of the correspondent expressions, without any sensation or consciousness of effort. On awaking he appeared to himself to have a distinct recollection of the whole, and taking his pen, ink, and paper, instantly and eagerly wrote down the lines that are here preserved. At this moment he was unfortunately called out by a person on business from Porlock, and detained by him above an hour, and on his return to his room, found, to his no small surprise and mortification, that though he still retained some vague and dim recollection of the general purport of the vision, yet, with the exception of some eight or ten scattered lines and images, all the rest had passed away like the images on the surface of a stream into which a stone has been cast, but, alas! without the after restoration of the latter!

Imagination, not reason, creates the novel. It is to social inheritance what mutation is to biological inheritance; it accounts for the arrival of the fittest. Reason or logic, applied when judgment indicates that the new is promising, acts like natural selection to pan the gold grains from the sand and insure the survival of the fittest. Imagination supplies the premises and asks the questions from which reason grinds out the conclusions as a calculating machine supplies answers. Wood's story of how a plausible answer to a perplexing problem came to him while dozing, only to be later exploded by his experiments, is illustrative. Dryden, presenting *The Rival Ladies* to the Earl of Orrery, said:

> This worthless Present was design'd you, long before it was a Play; when it only was a confus'd Mass of Thoughts, tumbling over one another in the Dark: When the Fancy was yet in its first Work, moving the Sleeping Images

of things towards the Light, there to be distinguish'd, and then either chosen or rejected by the Judgment.

And Coleridge's artistry has compacted the matter into the phrase, "the streamy nature of association, which thinking curbs and rudders."[1]

Some footnotes are in order. First, many have insisted that the imaginative process is different in art and in science. I see no basis for such a position. On the contrary, the creative act of the mind is alike in both cases, as the above examples and later considerations fully evidence. Rather, the criteria for sifting may differ. Both art and science demand meaningful relations; but the one is satisfied more by pleasing structure, the other by logical validity.

Second, it deserves mention that imagination re-enters at all stages of intellectual endeavor, it does not merely deliver a mental foundling to the care of other faculties of mind. In science, as an example, imagination enters into the devising of experiments or of apparatus or of mathematical manipulations and into the interpretation of the results so obtained. But these are likely to be minor miracles compared with the major insight achieved in the initial working hypothesis.

A third point: imagination is not encompassed in reason. True, reason gives "the truths no mind is free to reject," and logic is an index, through function, of how the brain machine is constructed. But logic can never reveal all the laws of thought, as George Boole hoped. For, in mathematics or symbolic logic, reason can crank out the answer from the symboled equations—even a calculating machine can often do so—but it cannot alone set up the equations. Imagination resides in the words which define and connect the symbols—subtract them from the most aridly rigorous mathematical treatise and all meaning vanishes. Was it Eddington who said that we once thought if we understood 1 we understood 2, for 1 and 1 are 2, but we have since found we must learn a deal more about "and"?

A final interpolation concerns imagination and knowledge. Imagination is one manifestation or index of how the brain machine works, which in turn depends on how it is built. And since sensory data are shaped by such reworking, imagination pervades all thought and knowledge. This is far from saying, as some do, that imagination offers a separate avenue to truth or reality, one alternative to sensation and depending on some act of spiritual apprehension or revelation or of ancestral or racial insight. Leonardo well said, "All knowledge is vain and erroneous excepting that brought into the world by sense perception, the mother of all certainty." What is denied our senses (or their instrumental extension) and what escapes through the meshes of "the a priori net of the mind," in Eddington's phrase, is lost to us. On the other hand, since the properties of nerve fibers and nerve cells clearly determine the character of sensation and, only less clearly with present knowledge, determine the character of imagination and reason, and since these last are called into action directly or indirectly by sensory nerve impulses set up by receptors which probe the surroundings, it is not surprising that sensing and thinking do jibe with each other and have some de-

[1] The mathematician John von Neuman has recently told me of a striking self-observation which indicates that even the curbing may be unconscious. The steps of a proof commonly enter his consciousness as a linked chain of steps, obviously in proper sequence in the unconscious but dragged into awareness (as if from memory) in haphazard fashion. When the whole has emerged and he finally writes it as an article, he occasionally develops a strong distaste for continuing this chore beyond some point. Experience has shown him that such a block almost always results in his discovering a previously unrecognized error at that step where the unreasoned blocking occurred.

gree of valid correspondence with a real universe.

Now, returning to the attributes of imagination, since its product enters consciousness abruptly, its workings are at the unconscious or uncritical level. As Lowes puts it,

> [Coleridge's notebook] gives us some inkling of the vast, diffused, and amorphous nebula out of which, like asteroids, the poems leaped. It makes possible at least a divination of that thronging and shadowy mid-region of consciousness which is the womb of the creative energy. For it is the total content of a poet's mind, which never gets itself completely expressed, and never can, that suffuses and colours everything which flashes or struggles into utterance. Every expression of an artist is merely a focal point of the surging chaos of the unexpressed.

Simple imagination is observable in a pure and untrammeled state in dreams, in the hallucinations of drugs and other agents, in those hypnagogic states which interpose between wake and sleep or in the slightly-fettered daydreaming while awake, in the free fancies of the child and the less free fancies of the amateur. For ideas, like mutations, are mostly bad by the criteria of judgment, and experience or expertness suppresses them—unless imaginings get out of hand and displace reality, as in the insanities. But the imaginative hopper is fed from and feeds back to the conscious and critical level. There the heat of mental work transforms the soft ingots of fancy into the hard steel of finished creations. Baudelaire refers to "the labor by which a revery becomes a work of art," and Mary Boole has likened the alternate conscious and unconscious digestion of a problem to the rumination of a cow—as indeed our language does in using "rumination" for a loose form of mental activity. I may also recall the famous descriptions of their own creative processes by two outstanding thinkers and a great composer. Claude Bernard says:

> Apropos of a given observation, no rules can be given for bringing to birth in the brain a correct and fertile idea that may be a sort of intuitive anticipation of successful research. The idea once set forth, we can only explain how to submit it to the definite precepts and precise rules of logic from which no experimenter may depart; but its appearance is wholly spontaneous, and its nature is wholly individual. A particular feeling, a *quid proprium* constitutes the originality, the inventiveness, or the genius of each man. A new idea appears as a new or unexpected relation which the mind perceives among things. All intellects doubtless resemble each other, and in all men similar ideas may arise in the presence of certain simple relations between things, which everyone can grasp. But like the senses, intellects do not all have the same power or the same acuteness; and subtle and delicate relations exist which can be felt, grasped and unveiled only by minds more perceptive, better endowed, or placed in intellectual surroundings which predispose them favorably.

Mozart writes to a friend:

> What, you ask, is my method in writing and elaborating my large and lumbering things? I can in fact say nothing more about it than this: I do not myself know and can never find out. When I am in particularly good condition, perhaps riding in a carriage, or in a walk after a good meal, and in a sleepless night, then the thoughts come to me in a rush, and best of all. Whence and how—that I do not know and cannot learn. Those which please me I retain in my head, and hum them perhaps also to myself—at least so others have told me. If I stick to it, there soon come one after another useful crumbs for the pie, according to counterpoint, harmony of the different instruments, &c., &c. That now inflames my soul, namely, if I am not disturbed. Then it goes on growing, and I keep on expanding it and making it more distinct, and the thing, however long it be, becomes indeed almost finished in my head, so that I afterwards survey it at a glance, like a goodly picture or handsome man, and in my imagination do not hear it at all in succession, as it afterwards must be heard, but as a simultaneous whole. That is indeed a feast! All the finding and making only goes on in me as in a very vivid dream. But the rehearsal—all together, that is best of all. What now has thus come into being in this way, that I do not easily forget again, and it is perhaps the best gift which the Lord God has given me. When now I afterwards come to write it down, I take out of the sack of my brain what has been previously garnered in the aforesaid manner. Accordingly it gets pretty quickly onto paper; for, as has been said, it is properly speaking

already finished; and will, moreover, also be seldom very different from what it was previously in the head. Accordingly I may be disturbed in writing, and even all sorts of things may go on around me, still I go on writing; even also chatting at the same time, namely, of hens and geese, or of Dolly and Joan, &c.

And Henri Poincaré makes a superb summary:

> This unconscious work . . . is not possible, or in any case not fruitful, unless it is first preceded and then followed by a period of conscious work. . . .
>
> It is certain that the combinations which present themselves to the mind in a kind of sudden illumination after a somewhat prolonged period of unconscious work are generally useful and fruitful combinations, which appear to be the result of a preliminary sifting. . . . This, too, is most mysterious. How can we explain the fact that, of the thousand products of our unconscious activity, some are invited to cross the threshold, while others remain outside? Is it mere chance that gives them this privilege? Evidently not. . . .
>
> All that we can hope from these inspirations, which are the fruits of unconscious work, is to obtain points of departure for [our] calculations. As for the calculations themselves, they must be made in the second period of conscious work which follows the inspiration. . . . They demand discipline, attention, will, and consequently consciousness. In the subliminal ego, on the contrary, there reigns what I would call liberty, if one could give this name to the mere absence of discipline and to disorder born of chance. Only, this very disorder permits of unexpected couplings.

Clearly, then, pursuit of imagination leads us into the unconscious and its mechanisms. Nor is this any longer a completely uncharted wilderness, for psychoanalysis especially has even now developed a usable body of knowledge to guide the explorer. It has recognized and isolated such unconscious mechanisms as condensation, displacement, projection, and identification—as well as repression, sublimation, substitution, rejection, denial, introjection, suppression, and conversion, to extend the list—which often enable the student not only to see further into the how of imagining but even to account for what is imagined. This is true for the normal and perhaps more strikingly for the disturbed; the previously meaningless chatter of the schizophrenic patient, for example, is quite intelligible in terms of known dynamics. Condensation and identification, respectively, are clearly revealed in the following statements by Coleridge concerning himself: "Ideas and images exist in the twilight realms of consciousness, that shadowy half-being, that state of nascent existence in the twilight of imagination and just on the vestibule of consciousness, a confluence of our recollections, through which we establish a centre, as it were, a sort of nucleus in [this] reservoir of the soul." And: "From my very childhood, I have been accustomed to abstract, and as it were, unrealize whatever of more than common interest my eyes dwelt on, and then by a sort of transfusion and transmission of my consciousness to identify myself with the object." And Lowes, in a painstaking study of the materials Coleridge had immersed himself in during the years prior to his writing "The Ancient Mariner," was able to trace to these sources every word and phrase of the poem's most vivid stanzas. As Lowes says,

> Facts which sank at intervals out of conscious recollection drew together beneath the surface through almost chemical affinities of common elements, . . . And there in Coleridge's unconscious mind, while his consciousness was busy with the toothache, or Hartley's infant ills, or pleasant strollings with the Wordsworths between Nether Stowey and Alfoxden, or what is dreamt in this or that philosophy—there in the dark moved the phantasms of the fishes and animalculae and serpentine forms of his vicarious voyagings, thrusting out tentacles of association, and interweaving beyond disengagement.

This is not, of course, to detract a grain from Coleridge's achievement; it is only a recognition and demonstration of the sensory components on which imagination operates. For the components had to be integrated, the poem given form. Again to quote Lowes:

Behind "The Rime of the Ancient Mariner" lie crowding masses of impressions, incredible in their richness and variety. But the poem is not the sum of the impressions, as a heap of diamond dust is the sum of its shining particles; nor is the poet merely a sensitized medium for their reception and transmission. Beneath the poem lie also innumerable blendings and fusings of impressions, brought about below the level of conscious mental processes. But the poem is not the confluence of unconsciously merging images, as a pool of water forms from the coalescence of scattered drops; nor is the poet a somnambulist in a subliminal world. Neither the conscious impressions nor their unconscious interpenetrations constitute the poem. They are inseparable from it, but it is an entity which they do not create. On the contrary, every impression, every new creature rising from the potent waters of the [unconscious] Well, is what it now is through its participation in a *whole*, foreseen as a whole in each integral part—a whole which is the working out of a controlling imaginative design. The incommunicable, unique essence of the poem is its *form*.

And Hartmann says:

Thus works ordinary talent; it produces artistically by means of rational selection and combination, guided by its aesthetic judgment. At this point stand the ordinary dilettante and the majority of professional artists. They one and all cannot comprehend that these means, supported by technical routine, may perhaps accomplish something excellent, but can never attain to anything great. . . . Combination procures the unity of the whole by laborious adaptation and experimentation in detail, and therefore, in spite of all its labour, never accomplishes its purpose, but always allows, in its bungling work, the conglomerate of the details to be visible. Genius, in virtue of the conception from the Unconscious, has, in the necessary appropriateness and mutual relations of the several parts, a unity so perfect that it can only be compared to the unity of natural organisms, which likewise springs out of the Unconscious.

Form, structure, relationship, organism (or org in my usage), part-whole systems, gestalt, or closure is basic for the product of imagination and for its process. To see star groups, constellations, instead of unrelated stars—the literal meaning of "consider"—is the gist of closure, of a confluence of elements. Since imagination only regroups sensory material, there is truly nothing new under the sun. Perception is really a harder problem, for red rays and green rays, even falling on separate eyes, do give the "new" sensation of yellow; but imagination cannot conjure a hue for ultraviolet. A mermaid, griffin, or centaur, as Lucretius recognized, are only recombinations of familiar elements. Yet when we recall that a single inning of a chess game may offer some four hundred choices, that all literature is built from the same words and these of the same letters, as all material is of the same elements and their handful of subatomic particles, novelty in combination does not seem too barren. A new and fertile pattern of thought may come from a conceptual reslicing of the universe into fresh classes and the making of new combinations of them. A good insight is likely to recognize the universal in the particular and in the strange—perhaps overexemplified in this statement by Coleridge:

My illustrations swallow up my thesis. I feel too intensely the omnipresence of all in each, platonically speaking; or, psychologically, my brain-fibers, or the spiritual light which abides in the brain-marrow, as visible light appears to do in sundry rotten mackerel and other smashy matters, is of too general an affinity with all things, and though it perceives the difference of things, yet is eternally pursuing the likenesses, or, rather, that which is common [between them].

A good insight generalizes progressively, as is so well illustrated by the growth of mathematics and the formulation of ever more inclusive and freer equations (e.g., the Pythagorian theorem) which can then be applied to an increasing range of particular cases. George Boole, for example, introduced modern logic by recognizing class as basic to, and more general than, number. Finally, a good insight sees (or foresees) in a welter of impressions that which is relevant to the goal earlier indicated by reason; it winnows the important facts from the unimportant. But now we are reaching the

domain of more formal psychological studies.

The Psychology of Imagination

The gestalt school of psychologists, especially, has emphasized the importance of closure or structuring—of "considering"—in insight. Insight is an imaginative way of learning or problem solving, in contrast to the blind and buffeted way of trial and error, often called "at-sight" for contrast. (A neurotic behavior development, inappropriate to the actual situation and, in a sense, no longer goal-directed, might similarly be called "out-sight.") Beyond sensation and even simple perception, involving the correlation of current sense data and of past experience, closure is a basic property of mind. It is, in Goldstein's formulation, the ability to separate a figure from its ground, to formulate a gestalt, or form, to identify an entity. (It operates in seeing three separated dots as the corners of a triangle.) From this flows the setting up of classes and the recognition of spatial—or temporal—relations. Thus Conrad notes the ability to combine parts or elements into a whole, to integrate systems; and also the converse ability to identify parts or elements in the whole, to fragment or differentiate systems. And Wertheimer further recognizes the ability to shift from one whole to another one, to restructure a system.

These activities may seem tautological restatements and are certainly closely related intuitively; yet, as we shall see, they enjoy considerable independence and can be separately measured. Most immediately exemplifying imagination would seem to be the last, flexibility of structure; for Wertheimer correctly says, "Creative thinking is the process of destroying one gestalt in favor of a better one." It is the highest imaginative achievement to be able to restructure in useful ways the basic propositions or axioms on which our great logical thought edifices have been erected. And, as an indirect sign that even such intangible mind work may still be sharply tied to the properties of the brain, there is the observation (Brickner) that stimulation of just one particular small region of the exposed human brain is able to arrest movement in thought. A conscious patient counts smoothly except while the electric current is acting, when the same number is simply repeated. Thus (with the period of stimulation italicized) the subject says, "1, 2, 3, 4, *4, 4, 4, 4, 4*, 5, 6, 7, ... "

Some examples of imagination at the comfortable and familiar level of parlor problems will serve best, perhaps, to illustrate the points made above.

The victim is asked to draw four straight lines which shall pass through all nine dots arranged in a square of three rows of three dots. The presentation sets the gestalt of the square, but within that pattern a solution is impossible. When the imagination overcomes this restriction, however, and extends lines beyond the self-imposed margin of the figure, the answer (Fig. 1) is given almost by inspection. Entirely comparable is the problem of constructing from six matches tossed on a table four equilateral triangles, each having its sides the length of a match. So long as the solver limits himself to the suggested plane of the table he struggles in vain; as soon as he adds a third dimension in his consideration the tetrahedron almost leaps at him.

Another shift in structuring is demanded by the match problem in Roman numerals, VII = I, the object being to move one match and make a true identity. Only after the figure is seen in terms of Arabic symbols can the solution follow, $\sqrt{1} = 1$. A last example of this sort is a geometric problem, commonly muffed by mathematicians no less than

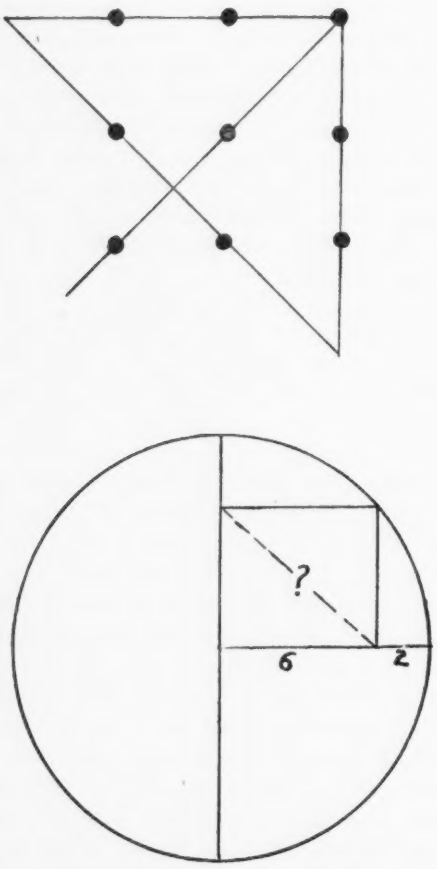

FIG. 1. PARLOR PROBLEMS

by ordinary folk. Draw the vertical diameter and a horizontal radius of a circle. The radius is, say, 8 inches, and at 6 inches from the center a perpendicular is erected from the radius to the circle, and from this point a horizontal line back to the diameter completes a rectangle (Fig. 1). The problem is to find the length of the diagonal connecting the corners on radius and diameter. The answer can be obtained by laborious calculation or, if one is able to flop over his pattern, by inspection; for the other and equal diagonal of the rectangle is simply the radius of the circle.

Of great elegance and beauty and demanding a high order of imagination or patterning is the problem of laying counters on a table. You and an opponent have an ample supply of round counters, all alike but of unspecified diameter, which you place at alternate turns in any desired position on a rectangular table of unspecified dimensions. A counter can be played so long as it does not touch one already placed (and not thereafter movable) or fall off the edge. The winner of the game is the one to play the last counter that can be placed. The problem is, Do you choose to make the first play or have your opponent play first? Surprisingly, there is a definitive and general solution to such a seemingly indeterminate problem, and it cannot be reached by trial and error but by an imaginative invocation of symmetry. You play first in the exact center of the table and you can always win. For at each round, wherever your opponent plays there is an identical position opposite (radially) open to you and will be until the end. Only the center is unique in a symmetrical figure; all other points can be paired.

The equation for sums developed by Gauss, supposedly when a school child, is a similar insight. Most of us, asked the sum of the numbers from 1 to n do an uninspired piecemeal job of addition. Gauss saw the problem in terms of equal number pairs: 1 and $n = n + 1$, 2 and $n - 1 = n + 1$, 3 and $n - 2 = n + 1$—which at once gives $n(n + 1)/2$ as the general solution.

A shift in frame of reference or structure is also involved in a good pun, which is similarly an imaginative creation. As examples, consider the victory garden slogan (spoonerized from the crap game cry), "Weed 'em and reap"; and a wit's responses when aroused from sleep to prove his pungency:

"Make a pun."

"Upon what?"

"On any subject, on the King."

"The King is no subject."

In contrast to the above instances,

many problems require essentially no imagination but either memory or reason. The great bulk of questions aired in quiz programs are ones of simple memory. A problem that can be solved without imagination is that of exchanging dimes and pennies. Three of each are lined up, with one central space vacant between the dimes and the pennies. Any coin can slide forward into a space or can jump over a single coin of opposite kind into a space. The necessary moves can be found by brute trial and error or, more simply, by a little reasoning; but the initial gestalt is retained throughout.

Numerous examples of insight could be given at the infrahuman level: Kohler's chimpanzees which "closed" two elements and brought a box and a stick to reach a banana; Yerkes' ape which, having accidentally whirled into the correct solution of a choice-of-gates problem, regularly thereafter whirled before trying the gate of his choice; Maier's rats which were able to combine "knowledge-of-general-maze pattern" and "block-between-me-and-food" and choose the shortest available path; and the innumerable animals that, during conditioning, seem suddenly to make the induction of "bigger-than" or "nearer-than" or "same-as" and thereafter give errorless performances. But a further pursuit of imagination in man will be more interesting.

If imagination is a definable property of the mind it should also be measurable; and as the definition progresses from the vague impressions of ordinary human dealings to that offered by standardized situations, so the measure moves from the subjective judgment of a person, as having a good or poor imagination, to a fairly quantitative statement about performance. Thurstone, especially, has pressed forward the analysis of mental abilities. By extensive testing with a rich variety of problems he has shown at least seven such abilities which are independent of each other. Thus, individual A may outperform individual B by ten- or a hundredfold on tests which utilize ability 1, while B may similarly outperform A on tests involving ability 2. A similar analysis has revealed some ten perceptual abilities, and others surely remain to be uncovered. Some abilities, such as those of word fluency or verbal understanding, depend for their exercise on learned language, and so performance improves over much of the life-span. But others, such as space visualization, show little improvement in their use after the age of six to eight years; in fact, performance may actually decline. The case for inborn capacities, of particular degrees for each capacity in each person, is thus strong.

Is imagination some one or several of these separable abilities or some common "power factor" underlying them? The answer is not yet available, but it is within easy grasp when persons of outstanding talents of various sorts are measured by such standardized tests. Meanwhile, some interesting guesses may be made. At least four of Thurstone's factors might be involved in imagination, and one of these seems almost to define it. The I, or induction, factor is the ability to see logical patterns or relations (and so would be less related to imagination than to reason). A convenient test for it is to have the subject supply the next item of a series. A very elementary series is: O X X O X X O X ?. A more severe demand is made by: 1, 7, 3, 6, 5, 5, 7, 4, 9, ?. The K factor, measured by the Rohrschach "ink-blot" test, is almost at the other end of the mental spectrum and, far from impinging on logic, plumbs the unconscious. It is of the free completion type; the subject is given an amorphous stimulus and allowed to react with no restraints—as when a person gazes into the flames play-

ing over a fire or at clouds drifting in the sky and "sees" castles or bears or witches acting out untold stories. It is suggestive that a group of successful executives performed (in richness, variety, etc., of responses to the ink blots) significantly above the average on this test.

Two other factors rather specifically deal with closure. The A factor is the ability to make a closure or complete a gestalt and is measured, for example, by having the subject identify partially erased pictures or words. The E factor is the ability to replace one closure by another and is tested by the Gottschalt figures (Fig. 2), or by "hidden faces" in a picture of different manifest content. The two abilities, especially E, are rather precisely those considered earlier in defining the act of creative imagination. It is impressive that two independent factors can in fact be isolated for such intuitively equivalent actions as making or remaking a closure! When such primary abilities have been measured in our Einsteins, Edisons, Toscaninis, Van Goghs, Masefields, and Lincolns we shall be far along the way. From descriptions of Coleridge, for example, there is little doubt that he would have performed very well indeed on tests for K, S (space), W (word facility), M (memory), and I and A.

"Zoology" of Imagination

The inheritance of imagination will be ever more easily studied as identification becomes more precise. Even now the comparison of the mental abilities in twins and in siblings is in progress. Pending such finer analysis, I may mention evidence that a strong hereditary element is present for "averaged" intelligence and for particular talents. Newman and Holzinger, for example, have found an average difference in I.Q. of 5.9 for identical twins raised together and that this value increases only to 7.7 for those raised apart. In contrast, fraternal twins raised together differ by 8.4, and sibs by 14.5 if raised together, 15.5 if raised apart. Orphan pairs differ by 17.7, whether apart or together.

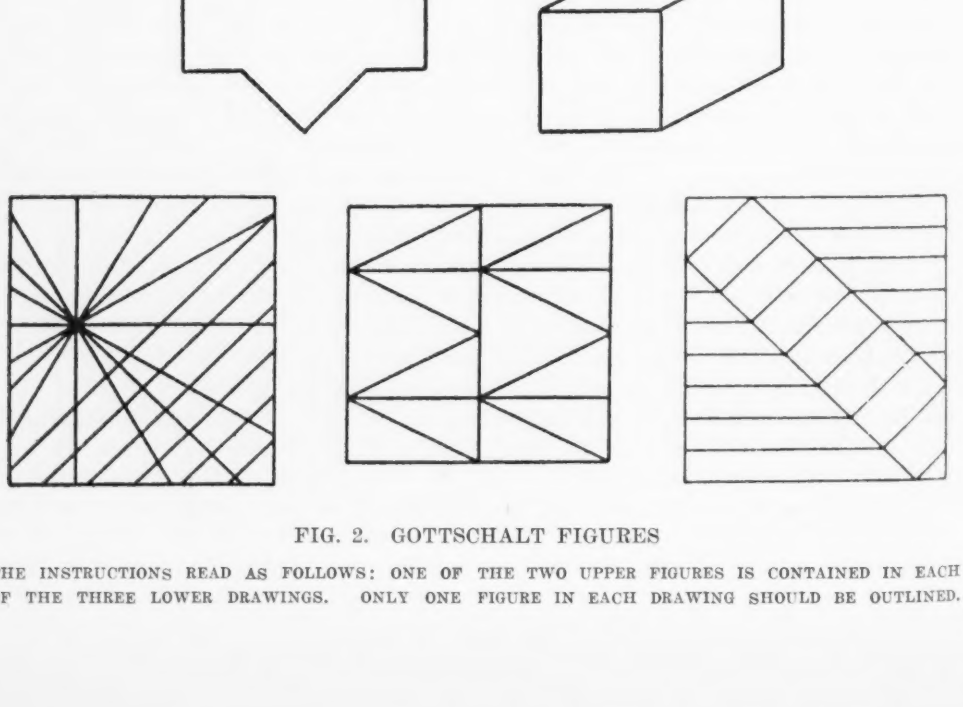

FIG. 2. GOTTSCHALT FIGURES

THE INSTRUCTIONS READ AS FOLLOWS: ONE OF THE TWO UPPER FIGURES IS CONTAINED IN EACH OF THE THREE LOWER DRAWINGS. ONLY ONE FIGURE IN EACH DRAWING SHOULD BE OUTLINED.

A study of outstanding contemporary virtuosi and singers by Scheinfeld shows that two-thirds of the parents of these artists possessed high musical talent. Conversely, in families with both parents talented, two-thirds of the children also were gifted, whereas in those in which neither parent showed talent (but of course one child was outstanding) only one-fourth of the offspring were gifted. He suggests that the minimal genetic interpretation of these facts is that musical talent demands the presence of at least two dominant genes. The importance of the hereditary factor is further attested by the age at which these outstanding musicians had clearly manifested unmistakable talent—an age under six years!

Interesting data in the field of science come from the starring results in *American Men of Science.* Mathematicians achieve their star at the average age of twenty-nine, with physicists close behind; botanists and geologists wait until they are fifty-two for the same kudos. All will probably agree that sheer imagination and intellectual power, as compared with experience and learning, are relatively more important in the former fields than in the latter. That the growth of mental *capacity* is more a matter of biological maturation than of life experience is suggested by all these findings, as well as by the high performance of children on some of Thurstone's factor tests. Similar conclusions in other fields of neural performance are justified by Coghill's evidence that salamanders kept anaesthetized during the developmental days when their fellow embryos struggle about "learning" to swim, swim well at once on ending their trance state; and by the fact that a normal human baby begins to smile at two months after birth, a seven-month premature, four months after birth.

A final comment in this area, on the evolution of mental abilities. Several men have attempted to construct a scale of comparative intelligence of animals in terms of such learning criteria as the maximum time over which a trace-conditioned reflex could be established, but without convincing success. That man's abilities differ in degree more than in kind from those of his slower-witted biological relatives is nonetheless probable. Apes show learning by insight as well as by trial and error and have even been taught to work for money as industriously as do their gifted cousins. Wolfe has trained chimpanzees to put counters into the slot of a vending machine to obtain food, different amounts for different colors. Having learned the purchasing value of these colored bits, the animals will do "chores" to obtain them and will work harder for the more valuable ones.

Since the gross and microscopic structure and the chemical and electrical functioning of the brain are measurably comparable in all vertebrates, reasonably alike in all mammals, and strikingly similar in the higher primates, where enormously detailed parallels have been demonstrated, a likeness in mental capacities is not surprising. The gray cortex of the cerebrum has swelled out from the primitive nerve cell groups to which came messages from nose, ear, and eye. These "distance receptors," sensitive to changes in the world at a distance from their possessor and so posing problems to the animal for a priori solution, somehow whipped into existence a brain capable of solving them. It is the same cerebrum in man and monkey; but man has a deal more of it, which permits rich additional permutations. And now that the brain is introduced into the picture, we must consider knowledge in the more medical areas.

The Brain and Imagination

Pathology. It remains sadly true that most of our present understanding of mind would remain as valid and useful if, for all we knew, the cranium were

stuffed with cotton wadding. In time, the detailed correlation of psychic phenomena and neural processes will surely come; but today we are hardly beyond the stage of unequivocal evidence that the correlation does exist. The neuroanatomist and physiologist are still crudely deciphering the architecture and operation of the organ of mind; the psychologist and psychiatrist are concerned with nuances in the overtones it plays. Yet the gap is narrowing, and a primitive bridge is offered by the grosser disturbances of brain and mind. Perhaps most dramatic are the aphasias, a group of disturbances in the ability to handle "meaning," associated with more or less sharply delimited regions of brain damage. Since disease or accident rarely destroys an exact division of the cerebrum and since different divisions have unique functions, the symptoms are commonly mixed and vary from case to case; but such a diagrammatic instance as the following has been reported.

An educated man, proficient in several languages, suffered a "stroke" which left him aphasic. At one stage in his slow improvement he could converse freely and intelligently but could not read. His vision was not disturbed; he could copy a paragraph correctly, but it carried no meaning to him. He was able, in fact, to take dictation in one language, translate in his mind, and write the correct passage in another tongue. But having written it, he could not read his own writing; it was Chinese to him! One is reminded of the small boy who, called on to read aloud in class, was asked the meaning of what he had read and gave the startled and startling reply, "I don't know. I wasn't listening." Another type of case, with disturbance more on the motor than the sensory side, could not give the word for 7 but could say it by counting aloud from one. Another, wanting to say "ruler" could not do so until he had made a sketch of one. Yet another could not say words but demonstrated, by holding up fingers for syllables, that he "knew" them. For example, "What is a baby cat?" No sound of kitten, but two fingers raised in response. Even when words remain, they are often inexact or roundabout, and the subject seems to be indulging in fancy speech or "overwriting," as shown by the following quotations from a patient during and subsequent to an aphasic episode: "I trust I am now learning to do my very best to secure the ideas to put myself carefully to operate the item to me which was seeming away when needed so much by me." And, later, describing his aphasic condition, "Personally I got dumb and could not remember things." (These cases are quoted from Weisenburg and McBride's *Aphasia.*)

As these instances show, there is commonly a disturbance in the use of language, but this is too limited a view of the defect. Language is man's main symbolic system, and aphasia has been considered as a disturbance in symbolism (Head) or in propositional expression (Jackson). But formal symbols are still but one avenue to meaning, and the others may also be disturbed in aphasia. A patient may fail to recognize familiar tunes, or may be unable to identify by touch a common object placed in his hand, such as a key or knife or pencil, although he recognizes well enough that some object is there and may name it at once on sight. Similarly on the motor side, a man could not at will move his tongue over his lip on instructions, which he understood, but could do so to remove a crumb placed there. Comparable defects in meaningfulness have been produced in monkeys by appropriate brain operations on the parietal lobes (Kluever and Bucy). Such an animal still sees and feels objects as well as ever, but it no longer recognizes them. It will pick up, bring to its mouth, and drop again, in interminable random activity, such normally intensely discriminated objects

as a banana, a stone, and a live snake. This behavior is in sharp contrast to that of a monkey whose visual sensory cortex (occipital) has been removed. Then, while light sensitivity is fully retained, as shown by eye reflexes, all visual perception is gone; the animal is effectively blind.

Thus meaning, in its widest sense, is imperiled by such brain insults, and the gestalt psychologists have not failed to point out that the very ability to create closures is damaged in aphasics. But, in man, language (with mathematics as one form of language) remains an especial index to the workings of mind; and Pick, combining philological study with his clinical observations, has formulated a series of stages in language use, which may be interrupted anywhere by the aphasic slash. On the sensory or receptive side there is, first, the perception of speech as distinct from mere sound. There follows the recognition of words as separate entities and then of the "musical" parts of speech, cadence, and intonation. Only then comes an awareness of meaning, followed by full understanding of sentences with their proper word relations and emphases. Turning now to the motor or expressive sides, the sequence is intuitive thought (also called verbalizing or inner speech), which becomes structured thought, and is then cast into the schema of a sentence, only after which are the actual words chosen and the result articulated. Aphasia may thus prevent sensation from emerging into meaning, meaning from eventuating in behavior, or meaning itself from coming clear. The last would be a disturbance in closure or structuring. This represents, perhaps, the basic disintegration of imagination. Imagination may be the word for that all-important no man's land between the end of the receptive process and the start of the expressive one.

The future is parturient with the answers. For the advance of neurosurgery is offering to study clean-cut cases of brain defects (or stimulation); patients with local brain amputations or incisions for tumors or infections or even, rather less soundly, for mental disturbances. And the advance of psychological measuring is supplying better precision tools with which to make the study. Thus, at the receptive levels, superficial damage to a region (17) of the visual cortex destroys color sensations but preserves pattern; more profound damage destroys pattern recognition as well while leaving (as in the monkey) light sensitivity. Comparably, direct stimulation of area 17 in a conscious patient produces an awareness of lights; when the next area, 18, is stimulated, the lights move about; and, if the next brain region is excited, complete pictures flash into consciousness —as of a man somersaulting toward the observer.

And at the integrative or imaginative levels of meaningfulness, we need only the results of applying the tests for primary abilities, especially for Thurstone's A, E, I, and K factors, to patients with specific brain operations to make a great step forward. Even now, Halsted has found a striking defect, in patients whose frontal lobes have been partly removed, in the ability to make categories. A normal adult, given a miscellaneous collection of familiar objects and asked to group them in as many ways as possible, can set up dozens of categories for grouping—by color, shape, material, use, and so on and on. The operated patient can make few, if any, groups. Now making groups or classes is a form of closure, and here again we see imagination crumbling along with the brain that spawns it. But we must look more closely at the structure of the brain and the problem of localization.

Anatomy. The introspective psychologists have distinguished between crude sensation, organized perception, and full-formed imagery on the sensory side;

reason, will, and action on the motor side. The boundaries are not sharp, to be sure, yet one can almost follow the one into the other on moving with nerve messages along the nervous system. From the single receptor, or sense organ —tactile corpuscle of the skin, eye, ear, etc.—comes but one modality of sensation—touch, light, sound. This has the attribute of intensity, given by the frequency or closeness with which impulses follow each other in each nerve fiber and, less, by the number of fibers activated. When the message reaches appropriate regions of the nervous system, the sensation also has its particular quality of touch, or pitch, and this much of pattern that a "local sign" is attached, so that the region of the body (touch) or receptor (eye) from which the messages come remains identifiable. As nerve fibers from receptors gather into nerve bundles (along with motor fibers for much of the way, but separating at the ends, especially where they join the central nervous system), sensory messages are grouped together either by modality, in special cases like those of seeing in the optic nerve and those of hearing in the auditory nerve, or more generally by region, as all the skin and other sensations from one finger in a particular nerve or nerve branch.

Yet as soon as these latter nerves enter the nervous system, mainly along the spinal cord, the relay fibers are shuffled about so that they also become grouped by modality. Thus, if a nerve to the leg is cut, some portion of the leg skin (and muscle) will have lost all sensation of touch, pressure, temperature, pain, position, vibration, etc. But if one of the relay bundles in the spinal cord is damaged, the entire limb will lose only the sense of touch or of pain or of position, as examples, depending on which part of the cross section of the cord is injured, while retaining the other senses unimpaired. When these second relay fibers pass on their messages to the third member of the team, in the thalamus at the base of the great cerebral hemispheres, there is another reshuffling so that region again enters strongly into the arrangement. And from here the nerve wires fan out to reach the cerebral cortex, each to its own particular spot.

Optic fibers run to the occipital lobe and are there ordered so that each region of the retina is represented at a roughly comparable position on the cortex. Fibers from the skin carry all the cutaneous sense messages, remixed as to modality, to the parietal lobe just behind the great Rolandic fissure, where the various body regions are neatly arranged in order; from the foot at the vertex of the brain to the head well down the lateral surface—as if a tiny and rather grotesque manikin of the body lay upside down (and right side left) on this region of the brain. Sound, smell, balance, hearing are similarly "placed" in given parts of the cerebral cortex, and, on the motor side, the body muscles are represented just in front of the cutaneous area, across the Rolandic fissure, and are ordered as a manikin in like fashion. Muscle sense, which tells us limb position, for example, overlaps the cutaneous and motor areas, again in the same order from foot to head. The spatial arrangement of entering nerve fibers in the auditory cortex is in terms of pitch, rather than of position and, just discovered, there is a double location for hearing—two distinct brain areas in each hemisphere.

These cortical areas to which sensory nerve messages are projected from the thalamus, or from which motor messages project through the thalamus, are called the projection areas. They occupy but a small portion of the cerebral cortex, being surrounded by various association areas; and indeed both the microscopic characteristics and arrangements of the nerve cells and the functional influences

that have been traced between them show that some half a hundred individual and distinctive areas are present in the cortex of man. Some of the association areas, in close relation to projection areas, are primary and concerned directly with an elaboration of the particular projected messages. More of them, the secondary association areas, are concerned with the most general interrelation and reworking of the elaborated sensory clues, present and past. Thus, referring again to the aphasias, destruction of the visual projection area (17) causes blindness; of the visual primary association area (18), a pure sensory aphasia (agnosia) for seen objects or symbols—inability to give meaning to written words; of secondary association areas, a greater or lesser loss in meaningfulness in general, an integrative aphasia (aconia). A pure motor aphasia (apraxia), like the pure sensory one, would involve a primary association area related to the motor area for, say, speech. Stimulation, conversely, gives lights (17), moving lights (18), and moving pictures, respectively, as described earlier.

Now what of sensation, perception, and the like, and especially imagination, in relation to this sketched-in organization of the nervous system? Clearly, a knowledge of structure and localization of function is not enough; for a single nerve impulse running in a single nerve fiber in one or another part of the brain is much the same thing, and a billion of them simply added together are only a billion of the same things. But nerve impulses are not simply added. Messages set up from a single hair on a cat's paw—by touching it with a hair on the observer's hand so lightly that the observer feels nothing—run up a sensory nerve fiber to the spinal cord and there "explode" into many impulses running up to the brain in many fibers, which further interact along the way. A person listening to a watch tick hears it as louder while a light is being looked at; and experiments on cats show a similar enhancement of messages in the auditory sensory paths when the nearby optic paths are simultaneously active. The point is that as sensory messages ascend toward and into the cerebrum they are not merely relayed and regrouped, they are also reorganized and reworked; in fact, we shall see they even reverberate.

What may be the conscious concomitants of these various stages of neural work is not known; but all the evidence suggests that they would rise in richness along with the intricacy of activity patterns in the nervous system. If awareness is the internal view of events or systems which are material to the external view, as many hold, then some protoconsciousness (probably not self-consciousness, or an awareness of being conscious) must exist in the simplest blob of living protoplasm or, for that matter, even in all substance. But, just as behavioral capacity leaps upward when a nervous system is present and again as each major improvement in it evolves, especially as the great cerebral cortex comes to flower, so subjective awareness does likewise. Some consciousness of sensation may exist in the spinal cord, as does some ability to recombine and learn, but this would be difficult to prove and is surely of negligible degree compared to what is experienced by man's brain. Nevertheless, the sensory messages from receptor through sensory nerve and spinal bundles probably represent pretty pure and raw (but unsensed) "sensation"—as suggested by some of the facts on the results of damage. And if they reach projection areas without much interaction with other activity patterns they will result in simple consciously recognized sensation. There is even some evidence that the most primitive undiscriminated "feelings," such vague discomfort as accom-

panies mild bowel cramps, may depend on older subcortical brain regions, such as part of the thalamus. If, however, they interact with other current sensory messages, and with the memory traces of past ones, then they are probably more of the character of perceptions, after moving on from the thalamus and into the projection areas. By the time the primary association areas are engaged, with their added complexity, imagery is probably also present.

A comparable but reverse sequence exists on the motor side, with drive or willing or maybe intuitive speech at the start and particular muscle contractions at the end; with the same possibilities of interruption along the way, grading from the aphasias to the out-and-out paralyses. Volition may be disengaged from motor expression in less drastic ways than by anatomical damage: a person recovering from the stupor due to inhaling concentrated carbon dioxide "wills" to move his hand in response to a request, but nothing happens for a minute or more when, to his surprise, the hand moves "of itself" (McCulloch). The leaden limbs of a nightmare, when the dreamer cannot run for his very life, may be a comparable neural block; at least in deep sleep the toe reflex from scratching the sole (Babinski) behaves just as it does when the motor pathways of the nervous system have been injured.

Between perception and imagery on the one hand and volition on the other lie the great mental territories of imagination and reason. It might be useful to consider imagination as the culmination of sensory events, reason as the origin of the motor ones. Or perhaps reason, with its attendant logic, verbalization, decision, and willing, is more properly the start of motor events, and imagination is the more pervasive and encompassing mind work which is the keystone of the sensory-motor arch. Men with moderately severe brain injuries may perform well on the usual intelligence tests, while falling down on those which sample imagination. Indeed, imagination may include a "power" factor of intelligence underlying the others, as Spearman believed, and depending on the mass functioning of the whole brain, as Lashley's work on animals suggests.

Certainly, as earlier outlined, imagination depends on sensory information. Man cannot see the world other than as it unfolds itself within the sensory projection areas of his brain. These determine his basic orientation to externality. In the very spatial arrangement of the areas of vision, skin, and muscle sense is embedded an unformulated geometry. The basic units of physical science are distilled from these areas: space (centimeters) from vision, touch, muscle sense, and the vestibular system (the balance organs located within the ear); substance (mass, grams) from smell, taste, touch, muscle sense, and, secondarily, vision—a congenitally blind person, on achieving vision, feels objects "hitting" his eyes until he learns to project his experience into the third dimension, as we all project the sense of touch to the end of a stick with which we explore the bottom of a pond—and perhaps, even, the notion of force comes from touch and muscle sense, of matter more from taste and smell; and time (seconds) most directly from hearing. At least, as evidence for this last, is the powerful reaction to heard rhythm, tapping to a tune, and the fact that a sound track of words or music run backwards is completely meaningless, whereas a reversed light track, though often ludicrous or impossible, is perfectly meaningful. Moreover, one's subjective judgment of time certainly depends on a brain clock, which runs fast in fever according to a precise mathematical function of the brain temperature (Hoagland). (In another, more fanciful, sense one might think of time running through the cortex from behind

forward. Sensations, from already past events, enter behind the Rolandic fissure; motor impulses, which will set off future actions, leave from in front of it.)

From space, mass, and time comes, in turn, the notion of entity—the basic gestalt of all and the first flutter of imagination. In this sense, that entity is given by the sensory organization of the nervous system, Kronecker's famous mathematical dictum takes on a profounder meaning: "God made the integers, man did all the rest." And, in supplying the substratum for thought, vision in man is surely of overwhelming importance. Our thought words are almost all of visual reference, although we do "apprehend" a meaning and refer to a "tangible suggestion" or a "weighty problem," and we may say of something, "it looks heavy or hard," but never that "it feels red." Brightman has written the telling paragraph, quoted below, on the indications from language; and Sherrington showed how the eye, the main distance receptor in the higher vertebrates, has dominated the evolution of the cerebrum.

A survey of language shows that many of the terms used by common men as well as by scientists and philosophers in expressing their fundamental concepts are words which point only to visual experience, away from the invisible experience of free, purposive valuing. . . . Even theoretic man has clung to the visual tradition, or as it has been called, "The Spectator Theory of Knowledge." A spectator is one who looks; theory means looking; knowledge is the only word here that originally allows a non-visual experience. Realism, of course, refers to the visible thing, the *res*. But even idealism is named from the root ἰδ, which means see. Intuition (*intueor*) is simply looking at what is seen; vision, that supposedly spiritual act, means only seeing (*video*).

No matter how intellectual we try to become, we cling to *insight*. We seem to walk by sight and not by purpose in our etymology. If our insight reaches its highest level, it is synopsis, in which the optical is evident (as vision is evident in the very word "evident"). The esthetic is often interpreted as having some relation to purpose; yet the Greek word means only what is perceptible to sense. Even imagination (*imago, imitor*), which originally referred only to likeness and might thus mean likeness in purpose or value, quickly came to mean the seen likeness of a visible object. A philosophy is a world view (*vue*), that is, something seen. Contemplation comes from *contemplor* (to gaze at). Consideration is from *considero* (to look at closely); an interesting hint at man's early stargazing, for *sidus* (star) is concealed in the word. Even the ultraphilosophical German word, *Vernunft*, derives from *vernehmen*, which originally meant to see.

The distinguished art critic Ivens has made the provocative suggestion that Greek art and architecture and mathematics are distinctly inferior to those of more modern times (a critical judgment which he supports in considerable detail) because the classic Greeks were essentially hand-minded (touch and muscle sense), and modern man, eye-minded. The former, he urges, gave the finite, discrete, and particulate; the latter, the infinite and graded. Aside from such historical evidence as the continuity implied in Zeno's paradoxes, this view seems unsound on a biological basis. Greek brains were built like ours, of the same human race; and an earlier race, Neanderthal man, had, if anything, a more emphasized vision than our own—at least the occipital lobe of his brain, with its visual areas, was mightily developed. True, individuals vary in the degree to which their imagery is visual, auditory, tactile, and the like (it might even be possible to measure this in terms of the relative strengths of the occipital (α) and the parietal (β) rhythms in their electrical brain waves); but this variation almost surely follows the chromosomes, alike in old or new Greeks

No, the more static constructs of the classical period are to be understood rather as an earlier phase of imaginative creativity. In all human thought, the constant is adumbrated before the variable (mathematics), statics before dynamics (physics), structure before func-

tion, and classification before relationship or evolution (biology). It is not surprising that this is so, for thus does the brain create imaginings: remember that stimulation of the visual projection area generates static lights; of the first association area, dynamic ones; and of the second association area, moving pictures!

Physiology. What, then, of the mechanisms of brain functioning, of the generation of thought? Granting, again, that the exact relation between neural processes and conscious events remains unknown, it is still possible to recognize some striking parallels. Are closure and patterning basic to imagination? They are simply shot through the entire feltwork of the nervous system! Not only in the large-scale organization we have already noted but in the small-scale one no less. True, particular nerve fiber bundles connect each of the separate areas of the cortex with all; many directly, the others by relays. True, some of the bundles carry messages which excite the nerve cells they reach, so that when cells in area X fire messages to area Y the cells in Y become active. But it is also true that comparable nerve bundles connect cortical areas with thalamus, with spinal cord, with all parts of the nervous system; so that a nerve impulse entering the central mass along any fiber path could, in principle, find its way by one route or another to every part of the nervous system. (And in fact, too, under some conditions; as when strychnine has rendered the whole neural apparatus more sensitive, and a slight irritation anywhere can set off a general convulsive reflex contraction of all the muscles of the body.) And it is further true that the nerve impulses running from area X may not excite but inhibit or suppress the cells in area Y so that these stop their current action and cannot be re-excited for a time. Thus, stimulating the arm region of the motor area (4) will cause arm movements; but stimulating a region (4–S) only a few millimeters forward will stop arm movements and even prevent further stimulation of area 4 from starting them. Surprisingly, although 4 and 4–S lie next to each other on the cerebral cortex, this suppressor action depends on a distant locus of interaction; and part of the interplay is via a complex relay path, from 4–S to deep cells in the cerebrum (basal nucleus) and from there to the thalamus and from there back up to 4.

Each nerve cell is so richly supplied by nerve fibers reaching it from all sorts of local and distant neural regions, reaching it and making functional connection (synapse) with it, that it is rather like an egg packed in sticky excelsior. Messages bombard it along these many paths, some pushing it to action and some to quietude, some perhaps powerful enough to tip the balance individually but most surely requiring the help of their like fellows. Further, the nerve cell is being influenced by the blood passing it, by the oxygen and sugar it receives, the salts that bathe it, the electric currents from its neighbors, the temperature at which it finds itself, by drugs which reach it. And from this welter of influences—its state of health, the condition of the environment in which it is living, and, particularly, the clamor of allied and opposed messages reaching it—from all this comes a single result: the cell fires messages along its own fiber to still other cells, or it does not fire. There is, to be sure, some gradation in number and frequency of impulses sent or in duration of inactivity and depth of inactivability, but essentially the balance is between action or no action. Just so the judge, depending on the state of his stomach, or the temperature of the courtroom, or the bombardment of arguments on each side of the case, renders a single decision for or against. (Freedom of the individual to make the decision is equally easy or

hard to discover in the nerve cell and in the judge.) It is the collective and patterned actions of the several billion nerve cells of our brains that determine our behavior and accompany our thoughts. We must explore further this neural patterning.

A few years back, the only well-recognized pattern was the reflex arc. A message entered along a sensory nerve, continued through the nervous system along direct or relayed connections, and finally emerged in a motor nerve. Except as messages were in transit, the nervous system was presumably quiet. Today we know, largely from the electrical pulses of the "brain waves," that nerve cells are continuously active in wake or sleep, and many beat on like the heart. In part, this beat depends on the chemical and physical state of the cell and its surrounding fluid; in part, on the nerve messages playing upon it. Suppose cell *A* sends its fiber to connect, among others, with cell *B*, *B* with *C*, *C* with *D*, and *D* with *A*. If *A* were once activated by a message from *X* it would excite *B*, and so through *C* and *D* be re-excited itself. Another branch from *D* might excite *Y*. Then, once started, such a circuit might continue active, with excitation going round and round like a pin wheel and throwing off regular sparks of activity on each cycle. Of course this picture is too simple—the circuit would not be set off so singly, it would vary in its path and speed of spinning, it would have to stop by cell fatigue or other impulse interference, it would involve many more cells and connections, were it to accord with the actual behavior of the brain. But what is important is that just such circuit patterns, with all the needed complexities, have been shown to exist and function in this manner (Lorente de No). Closure in mental processes, did we say? Here is closure woven into the very fabric of the nervous system!

These closed circuits are mostly over minute distances, in single centers of the nervous system, but comparable ones exist on a gross scale. In many cases, also, a nerve cell cannot be made to fire by impulses reaching it along a single fiber but requires a nudge from two or several arriving at the same time (the main effect of a single impulse is expended in a few ten-thousandths of a second) and even from different regions. Again, what a beautiful basis for making new gestalts or recombinations of sensory material! As one example, recall that light can make sounds seem louder; as another, how association areas rework and embroider the activity of projection areas. A further instance shows that messages from the frontal lobe of the brain, as well as from the optic nerve and thalamus, must reach the visual centers for them to become fully active; for after injury to the front of the cerebrum the field of vision is narrowed, even though the retina and its immediate brain connections to the optic brain areas remain intact (Halsted).

Several important interactions occur between the cerebrum and thalamus, besides those already mentioned. Through the latter pass all sensory messages on their way to the projection areas and to full consciousness; and in another part of the thalamus are coordinated the bodily responses and perhaps the subjective aspects of emotion and other primitive feeling. When the cerebrum of an animal is removed, affective behavior is grotesquely exaggerated; so nerve paths from the cerebrum hold the thalamus in check. Other fibers from the cortex can activate the thalamus, and, indeed, even as sensory messages relay up through this part of the brain, other messages coming down to it from the cortex can block or enhance their passage (Dusser de Barenne). Perhaps what we call attention is in action through these paths which functionally open or close the gates

of the thalamus and allow now one, now another, group of sensory messages access to the cortex and full consciousness while relegating the others to the fringe of awareness or even to the unconscious. (This is not to say that all cortical activity is conscious or self-conscious, for such is not the case. James's figure of consciousness, as a single lighted candle carried from place to place in the cavernous darkness of a great building, is still a good one.) And, a final example, certain paths from the thalamus radiate out to much of the cerebral cortex and, when stimulated, set the whole cortical sheet into vigorous electrical beating (Morison and Dempsey). Perhaps this mechanism is responsible for the overactive mind work that follows an emotional shock. Perhaps just this occurred in Goethe's brain when news of his friend's suicide "crystallized" the plan of "Werther" as, "the whole shot together from all directions and became a solid mass." And surely here again is a neural basis for closure.

Besides such provocative nerve messages, able to influence the action of millions of nerve cells, other integrating mechanisms exist in the brain. Waves of action can be made to travel slowly over the cerebrum, for example, even when all anatomical connecting paths have been severed. Electric currents are probably involved here, and, indeed, these are a major factor in that environment which influences the discharge of the single nerve cell and the coordination of the many. Electrical fields have been richly demonstrated in brains; have been shown to vary their pattern with state of activity, chemical environment, drug action, and the like (Gerard); and have even been successfully invoked to explain in detail a variety of optical illusions in man (Köhler). By such various mechanisms, then, great masses of nerve cells—the brain as a great unity—act together; and not merely do two or a billion units sum their separate contributions, but each is part of a dynamic fluctuating activity pattern of the whole. This is the orchestra which plays thoughts of truth and beauty, which creates creative imagination.

Plenty of problems remain; some demand attention. Most urgent to our present theme is how novel neural patterns originate, since they must accompany novel thoughts or learning in general. Much attention has been given to the phenomena of learning: by "at sight," the slow cumulation of a new "correct" response in the course of conditioning experience, the conditioned reflex; and by insight, the sudden grasp of a solution and abrupt performance of the correct response, the gestalt or closure or imaginative act. They seem very different, and, as Terman put it, conditioning serves admirably to explain stupid behavior; gestalts, intelligent behavior. The mechanisms may indeed be quite different, but it is possible, perhaps probable, that they are basically quite similar. In both cases, new functional connections must be established in the brain; and this process may be more gradual and cumulative in the case of insight than appears. For here, also, much brain work precedes the imaginative flash—the theory of gravitation may result only when the metaphorical apple falls on the prepared mind—and only when the process has progressed to some threshold level does it overflow into a conscious (self-conscious) insight.

So long as our picture of the nervous system was that of the telephone exchange, with reflex plugs all set and each sense organ subscriber connected with, and able to call to action, its allotted muscles, the appearance of new responses seemed to demand the presence in the brain of rather mysterious telephone operators to shift the plugs. Now, with our discovery of a far more fluid nervous system, one unceasingly active and with

neural and electrical messages rippling the whole into dynamic patterns, which flow from one contour to another as present influences play upon the condition left by past ones—with such a picture the arrival of new neural relationships is no great problem. Schemata have been offered—in terms of nerve impulse balance, electrical fields, fiber growth—which at least indicate reasonable avenues for further exploration. More difficult still is the question of whether the new closures come to occupy particular neural regions, whether experience is parceled out in brain cubbyholes from which memory can withdraw and examine one package or another.

The answer seems to be mainly No, but with considerable reserve. A conditioned reflex established exclusively via one eye or executed by one hand can be at once elicited through the other eye or with the other hand; a learned response to a particular figure will be given unhesitatingly when the figure is changed in size, color, intensity, position, and even, within narrower limits, contour. Yet in each of the shifts indicated, different particular nerve fibers and connections are involved, at least in part. Further, Lashley has shown that the learning ability of rats parallels the total brain mass and is decreased as the brain is whittled away by operations. But the loss is not greater when any one region is destroyed as compared to another nor even when extensive thin cuts are made rather than removing a compact lump. Yet even here there begins to appear some suggestion of localization, for, though removal of the visual cortex does not prevent a rat from learning a light-discrimination problem, it does wash out a previously learned problem of this sort. And recent work on animals like the dog, with more elaborated brains, suggests some striking localizations.

Thus Culler established a conditioned leg flexion by sounding a given tone when an electric shock was administered to the paw. The tone alone then led to flexion, unless this conditioned response was elicited for a number of times without being "reinforced" with the shock, in which case the response was temporarily "extinguished." This is all routine; what is startling is his report that he found a region of the cortex only two millimeters in size and lying in association areas well away from cutaneous, hearing, or motor areas, which, on direct stimulation, caused leg flexion in animals with an active conditioned reflex but which was inactive in animals in whom the reflex was extinguished or had never been established. Another report, by Martino, is perhaps even more dramatic. He performed his conditioning so that the right eyelid blinked when red light was shown, the left eyelid with violet light. He then put strychnine locally on the optic cortex of either the right hemisphere (connected to the left field of vision) or the left one. With the left side rendered overactive by the drug, red (but not violet) light led to eye spasms and convulsions; with the right side drugged, only violet light produced the response.

If such indications hold up, a rapid advance in understanding in this field is imminent. Perhaps learning is initially a function of the whole brain and as ephemeral as a pattern of activity. But even activity leaves some more permanent change in the active part—think of the hypertrophy of an exercised muscle. And brain regions which are most active in particular patterns—think of the nodes and internodes of crossed wave trains—might well acquire, with repetition of these patterns, alterations which are both more local and more enduring than the initiating disturbance. With such regions located it will become practicable to look for the kind of change which endures; change in chemical composition or metabolism, electric potential or resis-

tance, cell structure or connection, or whatever it turns out to be when found. The figure of a river and its bed, used so vividly by Child in picturing the general relation of structure and function, is apposite here. The river carves its bed and the bed controls its waters; only by their continual interplay can a particular system develop. The spring floods are mass responses of the whole to environmental conditions and are transitory dynamic patterns, yet they leave local and lasting changes. Where the waters pile up most and the currents are swiftest—where the activity disturbance is most extreme in a particular total situation, as the potential fields in the occipital lobe on visual stimulation—there are produced the washed-out banks or the undercut cliffs which determine the river's flow for decades to come—the concrete regional changes wherewith the past directs the future, the basis of memory.

A final problem before coming to the implications of our analysis: What is the neural basis for the striking quantitative differences between man and man in intelligence or in the several abilities which constitute intelligence or its component, imagination? Surely brain size as such is not the answer, as many studies have demonstrated. Perhaps absolute or relative size of the association areas would show better correlation with intelligence; or perhaps the richness of fiber connections and the architectural intricacy—as the more elaborate circuits make the better radios, large or small. And the factor of activity level is almost surely involved; not only the size and number of nerve cells but their rates of beat, maintained potentials, irritabilities; their functional vigor. This, in turn, depends on their composition (make what you will of the fact that the brains of women contain a higher percentage of lipins—fats—than those of men) and on their metabolism; and this, on the blood supply and the amount of oxygen and sugar it brings, on the salt and acid and other components of the tissue fluids, on particular stimulants or depressants, as the thyroid hormone or anesthetic drugs, and the like. The influence of caffeine, alcohol, strychnine, cocaine, morphine, hashish, absinthe, and mescaline on brain metabolism and activity are being steadily worked out; their dramatic effects on the mind, especially on hallucinations and imaginings, are commonly enough known and are also being further studied (Kluever). As the sets of facts are brought together new understanding will arise. Possibly from this direction we shall get a clue as to the finer differential between brains: what gives one man a vivid imagination but a poor memory, another an encyclopedic memory but dull imagination. And when that answer is at hand science will indeed have established the biological basis of imagination.

Implications

Without awaiting these riper fruits of research, some immediate morals are worth plucking. The ideas tossed into consciousness by imagination are, we have seen, overwhelmingly bad—untrue or unbeautiful—and must be curbed and ruddered by reason. Here, surely, lies a difference between the more imaginative initiator and the more rational critic. Formal education is directed to our conscious reason, which can at least be supplied with content and practice; if the more intuitive and unconscious imagination can be cultivated we have yet to learn the secret. There is the danger of reason stifling imagination, that "enterprises of great pith and moment" will be "sicklied o'er with the pale cast of thought." From the young, the naive, the dreaming, the drug users, comes a great spate of fresh imaginings, overwhelmingly dross but with those rare

grains of great insight yet more common than from the old, the critical, the staid, or the sophisticated. To teach rigor while preserving imagination is an unsolved challenge to education.

Again, each important advance in form, in structured truth or beauty, is the result of a new closure, of a fresh set of axioms; a better set, resulting from the greater knowledge and understanding built with the aid of those dying. The forming mind of the young can use the new as comfortably as the old, but the formed mind of the teacher cannot readily run along the new-gauge tracks. The concepts of infinity, relativity, indeterminism in the physical realm, as evolution in the biological, were difficult for the established generation, simple for the oncoming one. Yet unless we forever question the basic imaginative constructs of our predecessors we condemn ourselves to working at progressively more detailed and trivial levels, to filling in further digits past the decimal point. Recall Trotter's provocative statement:

> When, therefore, we find ourselves entertaining an opinion about the basis of which there is a quality of feeling which tells us that to inquire into it would be absurd, obviously unnecessary, unprofitable, undesirable, bad form, or wicked, we may know that that opinion is a non-rational one, and probably, therefore, founded upon inadequate evidence. Opinions, on the other hand, which are acquired as the result of experience alone do not possess this quality of primary certitude. They are true in the sense of being verifiable, but they are unaccompanied by that profound feeling of truth which belief possesses, and, therefore, we have no sense of reluctance in admitting inquiry into them.

In ethical and religious attitudes, even more, the axioms are set at childhood; the re-education of a generation of "Hitler Youth" gives little promise of success. Why, even in aesthetics we learn our particular values; the dissonances of a mere generation ago are consonances to ears of today. To preserve open-mindedness while teaching current systems is another unsolved problem of education.

A final word on creative imagination. Besides the intellectual factors, certain emotional ones are demanded. The unconscious work goes on only over problems that are important to the waking mind, only when the mind's possessor worries about them, only when he cares, passionately. As Pavlov wrote shortly before his death at 87, advising young men on the requisites for effective pursuit of science: "Third, Passion. Remember that science demands from a man all his life. If you had two lives that would not be enough for you. Be passionate in your work and your searchings." This is related to the conscious work recognized by Poincaré as preceding the unconscious work of imagination; another emotional factor is involved with the second period of conscious work which follows: courage. It takes courage to face the unfamiliar, to espouse the different; courage to fight one's own prejudices only less than those of others. Was it not a little child who first dared call the emperor naked? It took great fortitude for Kepler to adhere to his new notion of infinity (as the second focus of a parabola), for, as he said, "The idea seems absurd, but I can find no flaw in it"; just as it did for Galileo to murmur among his inquisitors, "Yet the world does move." Most of us will never achieve great imaginative insights; we might at least attempt to be tolerant of those offered us by others.

Somehow, "this power of human thinking . . . seems in times of emergency or conflict to leap ahead to new truth" (Dummer). Sometime, when research in this "constructive power of the unconscious" has increased our understanding of insight, man will more effectively guide his onward movement.

SCIENCE AND WORLD COMMUNITY

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H. G. WELLS once remarked that the fate of the world depends upon a race between education and catastrophe; but in view of the atomic bomb, he has more recently announced that catastrophe is obviously winning, since science and technology are developing more rapidly than man's ability to control them. Others, even more alarmist, have predicted that atomic fission will ultimately set off a chain reaction which will explode the entire planet.

Possibly we can dismiss this particular nightmare but we cannot easily dismiss this *type* of nightmare. Instead of predicting the total destruction of our planet, we may, like Wells, speak of the leveling of civilization in a vast chaos. All that we cherish may be destroyed because man's capacity to make scientific discoveries outstrips his capacity to control them.

Looked at in this context, the question what men shall believe acquires an incredible poignancy. Now as never before we must go back to fundamental questions. What is man—a soul, a mechanism, a psychophysical organism? What is man's place in the cosmos? What is the essential value of human life? What is the nature of the good society? What is the essence and destiny of civilization? Every struggle loses its meaning, every social movement its orientation, unless these questions be faced. Without a world view, strong enough to be the basis of civilization, we cannot substitute reintegration for the disintegration which has been at work for several centuries and which has led great nations into moral and intellectual barbarism. Without a different *sort* of world view than has been prevalent, we cannot make the arts of life prevail over the techniques of death.

It is possible that we shall have to go down to the very bottom of the pit where all faith and reason are lost. But it is a steadying thought that science has vast potentialities for good as well as for ill. Pure as well as applied science can help steady our nerves by giving us a new interpretation of the nature of things.

Apart from its technological applications, science has contributed in two essential respects to the establishment of a better type of civilization: first, in its content and, second, in its method. In content, science is providing a new view of the world and man's place in it, a realistic vision which emphasizes the interrelatedness of things and which thereby reinforces the cooperative ideal of human life. In method, science involves a broad community of interpretation, a world-wide fellowship of truth seekers; and it thus prefigures the cooperative organization of mankind. Its proper utilization, moreover, requires a gigantic effort at synthesis, so that the vast and ever-accumulating mass of scientific information can be integrated into a unified interpretation of reality.

As we study contemporary science and the philosophy based upon it, we begin to see an emerging synthesis of thought and action, a possible new basis of civilization. The core of this synthesis is a world view based upon two ideas. First, the world is a complex of interacting processes—everything is relational—nothing exists in bare abstractness, parted off from the rest of existence. Second, the world as evolving has various levels with distinct, irreducible

characteristics, such as the mechanical, the organic, the conscious. These two ideas coalesce into a single concept: the evolving multidimensional community of all human beings and, in an infinitely wider compass, of all the interacting entities in the universe.

Admittedly, we are here discussing not the technical content but the ideological implications of science. The two must be distinguished. For example, we can distinguish between the technical content of Newton's astrophysics and the ideological implications which Locke, Pope, Voltaire, the French Physiocrats, and Newton himself read into it. Society will always discover such implications, and we need not regret the fact. Certainly science is a better foundation than superstition for a comprehensive interpretation of reality. Admitting that "the new world view" which I shall discuss contains speculative elements, I believe that it involves no such misreading of science as the supposed implications of Newtonian physics to which I have just referred.

As far back as the Victorian period, the discovery by Maxwell and Faraday of the electromagnetic field represented a fundamental departure from the older physical notions of relatively discrete unchanging particles and external relations. Subsequently, physical scientists have built up a new type of "field physics" in which atoms or electrons are conceived to be interdependent events functionally dependent upon their spatio-temporal environment. As a result of the new concepts of space-time, of relativity, of quantum and nuclear physics, of the time and space rate of energy, of Heisenberg's principle of indeterminancy, the universe depicted by physical science has become radically different from the "world machine" of Galileo and Newton. This difference primarily involves the increased recognition of wholes and integral processes. The region, the context, the given totality, the space-time configuration, the emerging levels of organization have taken the place of the old rigid atoms, the empty, featureless space, the static order of events, the mere positions without contextual reference.

Similarly in biology there has been an increasing emphasis upon integral part-whole relationships, upon the idea of the organism, in which the whole in a sense is prior to and determines its parts; the idea of the ecological community, in which organisms socially live and function; and the idea of emergent stages in evolution, in which there are real creative syntheses and not mere additive resultants. Psychology has been slower in responding to formism, but even here there has been an increasing tendency (represented by many besides the gestalt psychologists) to think in terms of organic wholes and structural relationships. Likewise in the social sciences there has been a general revolt against discrete individualism and a marked tendency to think in terms of interdependence. Modern history and anthropology, moreover, have made us aware that our competitive economic order is only one among many historical systems, and that consequently our system is no more natural or immutable than very different cooperative systems, which similarly arise and perish. Everywhere in science the old fixed concepts and counters have broken down and a new world view is emerging.

If we analyze what is involved in this world view, we find four essential propositions. First, the universe exhibits a series of levels of increasing complexity and wider integration: electrons, atoms, molecules, simple cells, plants, animals, personalities, human communities. Second, there is a tendency for these levels to succeed each other in time, the more inclusive and complex levels emerging at a later stage of cosmic development;

and hence reality is dynamic and evolutionary. Third, the integration also occurs as morphological envelopes in space: societies enveloping societies which in turn envelop societies. For example, the body envelops the organ, the organ the cell, the cell the molecule, the molecule the atom, and the atom the electron. Fourth, each envelope and integrative level exhibits its own emergent qualities and laws. This means that every science has its distinctive methods and subject matter, corresponding to a certain level of emergence, so that it is a false reduction to maintain that sociology is "nothing but" psychology, or that psychology is "nothing but" physiology, or that physiology is "nothing but" chemistry, etc.

It follows from these propositions that idealism—the theory that all reality is mental—is improbable, since mind apparently emerges out of, and is dependent upon, a high level of biological complexity. It also follows that any *reductive* mechanism or materialism—the theory that all reality is merely physical—must be rejected, since biological, mental, and social qualities, with the values and purposes to be found at the higher levels, are quite as indefeasibly real, although not as widely dispersed, as any chemical and physical processes. Thus both a *leveling up* and a *leveling down* interpretation of science and reality must be abandoned in favor of a theory of *distinct, graded, and progressive levels.* Finally, it follows that the world is to be interpreted in terms of a flexible organicism, since nature as a whole exhibits a nisus toward social organization.

A possible objection to the above interpretation is that discrete mechanism never has existed in pure science, and that real scientists have always taken account of systematic wholes, interactive elements, and emergent characteristics. Professor Gustav Bergmann, one of the ablest of the logical positivists, for example, objects to "the exaggerated importance" that the gestalt psychologists such as Wertheimer attach to the idea that a composite effect is not the additive sum of partial effects. He writes:

> What Wertheimer and his students so emphatically assert is essentially this. If C_1 causes E_1 and C_2 causes E_2, then the simultaneous occurrence of C_1 and C_2 does not as a rule cause the occurrence of E_1 and E_2. . . . To give an illustration which is drastic but, I believe, not unfair: a dog which has been appropriately trained runs away from his master when shown a stick and approaches a piece of food held out to him. If both stick and reward are shown to the animal, will it both flee and approach his master? Obviously not, but whoever said it would? . . . There is never any a priori reason to assume that the joint effect will be the logical conjunction of the partial effects. If addivity is the name for such unjustified inference then all empirical laws, whether elementaristic or organismic, are superadditive, and the thesis fights a straw man (Holism, Historicism, and Emergence. *Philosophy of Science,* Vol. II, 217, October 1944).

Such criticism is extremely valuable in forcing scientists and philosophers more carefully to define their concepts, but it does not—nor was it intended to—disprove the fact that a fundamental shift in the ideology of science is occurring. I have already distinguished between the *ideology* of science and the *technical content* of scientific laws. Granted that science in its laws has always taken account of the superadditive composition of forces, it remains nonetheless true that ideologically we are shifting to a greater and greater emphasis upon form, pattern, creative synthesis, communal relationships, and total configurations. Even in its strictly technical content, science has been affected by, and has participated in, this shift. The insight that the influence of the whole must be kept in mind in order to explain the character and activity of any actual part has had an increasing effect upon both laymen and scientists,

and consequently such fictitious entities as rigid atoms and completely egoistic human beings have been banished to the limbo of superstition. The extent of this shift can be exaggerated, but the shift is indubitable.

Many laymen and some few scientists, however, still interpret plant and animal life almost exclusively in terms of an individualistic struggle for survival. This tendency goes back to fundamental Darwinian concepts: "chance variation," "natural selection," and "survival of the fittest." One of the classic, although inaccurate, interpretations of Darwinism is Thomas Henry Huxley's essay *Evolution and Ethics,* in which "the gladiatorial theory of existence" is presented in terrifying terms. The law of nature, he tells us, is "ruthless self assertion," the "thrusting aside or treading down of all competitors." In this process, the strong and aggressive trample down the weak, and in this sense only do the "fit" survive.

The ethical reactions to this theory differ according to individual predilections. Huxley, for example, believed that man's duty is to maintain, with lonely and pathetic idealism, a Promethean defiance of nature and of nature's laws. "The progress of society," he declared, "depends not on imitating the cosmic process, still less in running away from it, but in combatting it." The more common view was that of Herbert Spencer, who argued that if human beings break with nature, nature will break them. Darwinian concepts, when applied to society, were almost always used to support individualism and predatory behavior: to oppose social humanitarianism and to rationalize war, imperialism, and exploitative capitalism. Even in very recent years, the same point of view has been maintained by Oswald Spengler, with his theory that man is "a beast of prey," and by the fascists, who adapted this doctrine to their own purposes. Hitler declared: "The whole of nature is a continuous struggle between strength and weakness, an eternal victory of the strong over the weak. . . . There is no humanitarianism but only an eternal struggle, a struggle which is the prerequisite for the development of all humanity" (*Hitler's Words.* Washington: American Council on Public Affairs. 3–5. 1944). In less exaggerated form, the same doctrine has become part of the folklore of American capitalism. "You can't make the world all planned and soft," says the typical businessman of Middletown. "The strongest and best survive—that's the law of nature after all—always has been and always will be" (R. S. and H. M. Lynd. *Middletown in Transition.* 500. New York. 1937).

Since the time of Darwin, however, a vast amount of evidence has been amassed to show that not only struggle but mutual aid is a major factor in evolution. A notable succession of books, such as Drummond's *Ascent of Man,* Cresson's *L'Espèce et son Serviteur,* Kropotkin's *Mutual Aid,* Thomson and Geddes' *Life: Outlines of General Biology,* and Conklin's *The Direction of Human Evolution,* have maintained that parental care, kin sympathy, altruism, and mutuality are potent factors in survival and evolutionary development.

In an article which reviews the evidence, Dr. W. C. Allee, a distinguished American biologist, concludes:

> The picture that emerges from the cumulative studies on social biology is one in which cooperations and their opposite, disoperations, both exist. There are both egoistic and altruistic forces in nature, and both are important. The question arises insistently as to which of these is the more fundamental and potent. . . . After much consideration, it is my mature conclusion, contrary to Herbert Spencer, that the cooperative forces are biologically the more important and vital. . . . Under many conditions, the cooperative forces lose. In the long run, however, the group-centered, more altruistic, drives are slightly

stronger. If cooperation had not been the stronger force, the more complicated animals, whether arthropods or vertebrates, could not have evolved from the simpler ones, and there would have been no men to worry each other with their distressing and biologically foolish wars (Where Angels Fear to Tread. *Science*, 97, 521. 1943).

Allee's careful conclusion is fairly typical of the opinion of contemporary biologists, who regard the views of Huxley, Spencer, Spengler, and Hitler as a one-sided exaggeration and caricature of nature. At the 1940 meeting of the American Association for the Advancement of Science in Philadelphia, there was a symposium on "Science and Ethics" in which some of America's most distinguished scientists, including a number of eminent biologists, agreed that human cooperation is a more important factor in survival than human competition. The more sophisticated biologists, moreover, realize that the life of man in society, although it necessarily rests upon a biological foundation, exhibits many cultural characteristics which cannot be reduced to merely biological terms. The direct study of human society by anthropologists and other social scientists has proven that "human nature" is remarkably plastic, and that the highly cooperative society of the Arapesh in New Guinea, for example, is quite as "natural" as the fiercely competitive society of their near neighbors, the Head-Hunters.

In view of the newer trends in both the physical and biological sciences, we can say that our tendencies toward community are as innate and as well founded in nature as any of our competitive drives; and that our problem is to keep competition in its proper place, directing it toward worthy ends and subordinating it to, or coordinating it with, the even more fundamental tendency toward organic and communal relationships. The most fruitful kind of competition, such as the friendly rivalry of scientists in the discovery of truth, is the sort that contributes to a common cause and that consequently is not an alternative to cooperation but an aspect of it.

The change in the ideology of science is correlated with a very profound transition in social thought and action. A new collectivistic order has been growing for many decades within the womb of the old order. We can see the signs of this growth in the social-mindedness of various modern thinkers—for example, in far-seeing economists such as Veblen and Keynes, in adventurous sociologists such as Geddes and Mannheim, in influential philosophers such as Dewey and Whitehead. We can see the same trend in the increasing emphasis upon planning, organization, and social control in all of the social sciences. We can discover the signs of transition, sometimes cruel and perverse, in the collectivist revolutions and political upheavals of the modern world.

After considering recent scientific and social tendencies, the English biologist, Joseph Needham, declares:

It may be that we are on the threshold of a long period, lasting perhaps for several centuries, in which the organic conception of the world will transform society, giving it a unity more comradely and equal than feudalism, but less chaotic and self-contradictory than the centuries of capitalist atomism (A Biologist's View of Whitehead. In A. Schilpp, Ed., *The Philosophy of Alfred North Whitehead*. 251. Evanston. 1941).

This very interesting sentence requires elucidation. Needham, I am sure, does not mean to imply that "the organic conception of the world" will, in and by itself, transform society. He elsewhere recognizes the decisive role played by economic causes in any such fundamental change. He means that the "organic conception" prefigures and facilitates this profound alteration.

Also he does not mean to imply that society is a giant organism, a kind of

monstrous leviathan with a soul of its own. The term "organic" is so loaded with biological connotations that we must use it with extreme caution in connecting it, as Needham does in this passage, with a human social organization. Society is to be conceived as an integrative structure the members of which are bound together by social relations which determine their essential personalities. Outside of these relations, they would be very different, if indeed they could even exist. Such "internal," or essential, relations, as opposed to merely external and inessential, are often called "organic," and there can be no valid objection to the term if the reader clearly understands that groups without being literally organisms may have a touch of the organic, some more and some less.

If we are not to misunderstand Needham and to misinterpret the nature of the new scientific "world view," we must recognize that "organic," as he and I employ the term, must be understood in terms of different grades and types of unity. First, a part may be related to a whole in such a manner that its normal characteristics and activities will remain virtually unchanged whether it is "in" its normal whole or not. An example of a part thus externally related to its "whole" is provided by the archaic conception of a rigid, unimpregnable atom grouped with like atoms in the extrinsic, indifferent receptacle of space and time. Any such whole is a mere aggregate, and no one would call the functional and existential *independence* of its part an "organic" relationshp. Second, a part may be related to a whole in such a manner that it undergoes an *internal* change, small or great, when it is isolated. Such *functional dependence,* which admits of infinite degrees from near independence to very close integration, can be called "organic" in the wide and sometimes metaphorical use of the term. Third, a part may be related to a whole in such a manner that it becomes quite unrecognizable, or cannot even exist, when isolated. This *existential dependence* can be called "organic" in the strictest sense of the term. Science is now recognizing that, although some wholes are mere heaps or collections in that they exhibit only the first type of unity, a vast number of wholes, and indeed such fundamental "kinds of things" as atoms, molecules, cells, organs, organisms, minds, and societies, can be fully described only in terms of the *second* and/or *third* types of unity. The increasing emphasis in science and philosophy upon functional and existential dependence constitutes a profound revolution in human thought; and it is this emphasis that I have in mind when I speak of the rise of "a new world view," and that Needham has in mind when he speaks of "the organic conception of the world" that modern science and philosophy have given us. (*Cf.* J. Needham. Integrative Levels: A Revaluation of the Idea of Progress. *Modern Quarterly,* Vol. I, 32–33, January 1938.)

He is surely right in prophesying a revolutionary change in human thought and institutions. We seem to be involved in the most rapid and profound change that humanity has ever experienced. Some kind of new order, therefore, is inevitable, whether for better or worse; but we can understand its necessities, appreciate its potentialities, and contribute to its values. If we are guided by understanding and motivated by good will, we can not only mitigate the cruelty of the transition but gradually build a humane and cooperative order. There is nothing, as we have seen, in our scientific understanding of man and his place in the universe that need discourage us in such an attempt. The ideal of a universal human fellowship is based upon the nature of things.

If we turn from the *content* to the *method* of science, we find that it involves, to employ the suggestive phrase of Josiah Royce, "a community of interpretation." To understand what is meant by this phrase, it will be helpful to analyze the nature of ordinary thought.

If we attend to any immediate object of awareness, to *this* patch of color, *this* rustle of leaves, *this* twinge of pain, it is always a particular and private datum: a different impression than appears at any other moment or to any other man. As soon as we *think* about the object, however, we relate it to various other objects: we connect the immediately given with the non-given. "This moment" is identifiable as *this* moment only because it stands in contrast to a moment ago which I now remember and the next moment which I anticipate. "This room" means "this" to me only because I think of some other room, and it means "room" to me only because I think of the house and of the fact that this is *a* room: an example of a class, a particular instance of a universal. To sever all such connections would be to render experience meaningless, to eliminate experience at the *human* level of insight. All our thinking, as Kant long ago demonstrated, is thus contextualistic: every object has meaning only through its social relations with other objects.

The context within which an object acquires meaning, moreover, is not merely the individual's private experience but the shared experience of a group of people. Despite the fact that individuals see objects in egocentric perspective, they interpret the objects as the "same" for all perceivers. At dinnertime, you and the other members of your family, for example, believe that you are in the same room and are eating at the same table, and the stubborn privacy of each of your immediate sensations does not prevent the subconscious creation of this community of interpretation. The ordinary objects of touch and sight and sound are regarded as essentially common objects, the "same" for all who experience them, because all of us fit our experiences into the wider social context of group experience, interpreting our private data as "aspects" of a common world. Without collating our experiences with those of others, we could engage in no conversation, no intercourse, no communication of any meaningful kind with other human beings.

Without this social interchange and correlation of impressions, moreover, there can be no meaning attached to the "external world": the environment in which we all move, breathe, and have our being. As Royce pointed out, the only reason we have for supposing that the moon is not just a chimera of private perception, such as "the nonexistent color" seen by the color-blind person, is that others see the "same" bright disc and its effects: it is witnessed by the testimony of innumerable human beings and hence is part of the "real world."

Thus there is a close connection between the quest for truth and the creation of a community. This is the reason why, again and again in the history of human thought, the masters of truth have created a community of "seekers." Pythagoras, Plato, Epicurus, Jesus, Confucius, Buddha, Marx: these are only a few of the men that founded communities for the cultivation of insight. An integral part of the "Socratic method," for example, is inquiry in common among a group of men bound together by love of philosophy and love of each other. If it is no longer necessary for a modern thinker to create a community, it is because science and education as now organized are essentially communal: but the community of learning is as yet embryonic and needs to be nourished.

Science is essentially a community of

interpretation when elaborated systematically and critically. The effort of science is primarily *to connect:* it is concerned with the whence and the why and the whither of things; with the causal relations of an object with a great many other objects in the universe. In elaborating its web of causal connections, science makes use of hypotheses which become established theories when verified. The degree of verification increases when the theory unites a greater number of relatively independent data, when it is, in this manner, both coherent and comprehensive. Newton's mechanics gains immensely in cogency when it not only serves to unify the area of mechanics but the hitherto unrelated area of astronomy. Darwin's theory of organic evolution similarly acquires strength when it not only unifies the data of paleontology but the previously independent data of embryology. Thus the method of science, like the method of common sense, is *contextualistic:* it always seeks to establish interdependence between hitherto independent data; and it is a better theory if it does not sacrifice unity for diversity or diversity for unity. In this respect, science is like art: in both fields, greatness is the result of the most perfect reconciliation of "opposites": unity and variety, parsimony and adequacy. The very structure of science is a kind of organized "community" of facts: it is a form that is more inclusive without being less harmonious, a rich variety brought to a focus.

This method of contextualistic interpretation always involves reference to the perceptions and judgments of others. Science is the coordination of facts, and the very meaning of a fact is that it can meet the test of *social* verification. The distinguishing mark of scientific theory, moreover, is its public character, the result of a process of abstraction, generalization, and collective verification; because no belief has scientific validity so long as it remains private, the esoteric object of a single individual's perspective. It must be transmitted and interpreted to others and substantiated by them: it must be verified by stubborn and irreducible facts, admitted to be such by all qualified observers. It must, moreover, be consistent with established laws and theories, which in turn have been verified by scientists living and dead.

Because of the social nature of scientific method, every scientist must submit his personal observations and conclusions to the scientific community. For example, Professor Charles S. Minot, a distinguished anatomist of the last generation, concluded a series of lectures with these words:

> I do not wish to close without a few words of warning explanation. For the views which I have presented before you in this series of lectures, I personally am chiefly responsible. Science consists in the discoveries made by individuals, afterwards confirmed and correlated by others, so that they lose their personal character. You ought to know that the interpretations which I have offered you are still largely in the personal stage. Whether my colleagues will think that the body of conceptions which I have presented are fully justified or not, I cannot venture to say (quoted by J. Royce. *The Problem of Christianity*, Vol. II, 225. New York. 1913).

This statement is the mark of a scientific man.

Therefore science, like common sense, is essentially social in method: the difference being that science involves a much more elaborate correlation and comparison of social perceptions and judgments: a collective historic process knitting together many generations of all races and nationalities. The members of the scientific community are nurtured in a common tradition of thought: they are joined together not by force or herd-mindedness but by a common interest: the capacity of each for original thought and invention is a source of enrichment

to all. These are the marks of a very high type of community. Such unity-in-diversity, transcending the barriers of race, nation, and class, is the very prototype of the ideal community: the worldwide voluntary fellowship of mankind.

THE specialized and analytical character of most contemporary science, however, tends to counteract the communalizing and integrating effect of scientific method. So prodigious has become the accumulation of scientific data and research that it requires innumerable digests, abstracts, indexes, bibliographies, and bibliographies of bibliographies merely to keep some record of the ever-increasing mass of specialized research. Since life is too short to master more than a tiny fraction of this material, each scientist is inclined toward an ever-narrower specialization. Learning "more and more about less and less," he at last reaches the rather pitiful state of being unable to communicate with, or understand, his close professional colleagues. His "research" is understood by only a few initiates and is abacadabra to all other scientists, not to mention the general public. Digging away in his narrow vein, he may penetrate ever deeper into the mine of knowledge but he never comes up to the surface, to the point of vantage for a general survey. If not all scientists are to be characterized in these terms, at least far too many can be so described.

In consequence, the fast accumulating mass of information remains an uncoordinated aggregate, a chaos of "facts" rather than a unified body of culture. The layman, even more than the scientist, finds that the universe of knowledge has broken apart into a chaotic multiverse. In books, magazines, newspapers, and radio broadcasts he receives innumerable scraps of information about the nature of the world in which he lives; but the very multiplicity of facts that crowd in upon him serves to confuse him the more. His knowledge, in consequence, is as superficial and uncoordinated as it is diversified. He can no longer simply fall back upon scripture and immemorial tradition: the problems that confront him are too new and complex thus to be resolved; the transition from an old world to a new has gone too far. Lacking the traditional anchorage and any fresh grasp of the inner coherence of reality, he is an easy convert to irrationalist and antisocial ideologies, such as anti-Semitism. If we are to escape such intellectual and moral anarchy, we must somehow diffuse among both scientists and laymen an understanding of the ultimate and general frame of existence. Unless in thought we can master our world we shall not be able to control it. What is required, therefore, is a great work of synthesis and general education.

Maintaining that scientists must create "an orderly world mind" to supplant the present "world dementia," H. G. Wells has suggested various devices to facilitate this task of synthesis. He has re-emphasized the importance of an international language, such as Esperanto or Basic English, which, like Latin in the Middle Ages, would serve as a basis for the free international exchange of ideas. He has proposed a World Encyclopedia, not a mere mass of unrelated articles arranged in the specious order of the alphabet but a coherent expression of the spirit and best insight of the age. He has also suggested a great World Institute, which would prepare digests and syntheses based upon research and thinking everywhere and which would systematically serve as the "world's memory." Such an Institute would employ the most modern methods for the recording and dissemination of information, as for example microphotography, which enables the contents of a large

library to be condensed in a small box and inexpensively to be reproduced in various parts of the world.

Such proposals could prove extremely valuable, but less mechanical and more fundamental is a profound intellectual reorientation: "a unified approach to knowledge and life." The conception of knowledge as an organic unity, "a system consisting of parts, related to one another, and interpretative of one another and the unity of the whole," must penetrate all the levels of science and education. (*Cf.* L. Mumford. *The Unified Approach to Knowledge and Life.* Stanford. 1941.) As a distinguished English physicist, J. D. Bernal, remarks, specialization has been carried so far that there is

> an enormous lag in the appreciation of the relevance of one field of science to another. For instance, chemists for a quarter of a century have failed to recognize that advances in physics and crystallography require not merely the revision but the complete recasting of the fundamental structure of their science, nor have the mathematicians appreciated the extraordinarily rich fields offered to them in the recent studies of the development of organisms. One effect of this is to hold back science just at those very places where its advance is most needed: the regions between recognized sciences (*The Social Function of Science.* 114–115. New York. 1939).

Already the interpenetration of the sciences, however, is being more fully recognized, as for example in recent biochemistry, biophysics, psychosomatic medicine, social geography, and broad humanistic studies such as culture-history. In consequence of this increasing appreciation of the unity of knowledge, a considerable number of educational institutions are abandoning the chaotic "elective system," whereby bewildered students encounter a haphazard succession of isolated "subjects," and are substituting an integrated curriculum.

Although such cross-fertilization of the sciences and integration of educational courses are extremely valuable, they must ultimately depend upon a comprehensive and dynamic synthesis. A detailed synthesis, as contrasted with the brief sketch which I have included in the present article, is very difficult to achieve. If we are to have a reliable "world view," the known universe must be "our oyster." We must intellectually possess it; we must understand it entire. To achieve this grasp is the task of a Titan, beyond the compass of any living man. Aristotle in ancient Greece or Aquinas in the Middle Ages could sum up the total view, but the world as then understood was far more simple and synoptic. We must now rely not upon a single great interpreter but upon a community of interpreters. We must no more give up the search for unity of thought than did men in ancient times but we must realize that the task now devolves upon an organized band of truth seekers, supplementing and complementing and qualifying one another's vision.

Many scientists have cried out with alarm against the proposal that they work together in an organized way, as in large measure they have been doing in wartime. These protests are parallel to the many attacks upon planning in the economic and political sphere. They are based upon the false premise that freedom is inconsistent with organization. The fact that this premise is false we can see from many ordinary activities, such as a public dance, a baseball game, or an orchestral concert—from any cooperative activity in which order and individual expression are reconciled.

There is danger, of course, that men of thought will be tragically constricted by the forms of social organization: certainly this has occurred to a terrifying degree in certain parts of the world. The remedy is not intellectual anarchy because it brings the very tyranny to which we object: the real remedy is the interpenetration of so-called opposites,

the achievement of free organization and organized freedom; not the buckling of minds to a preordained plan, but the creation of a plan by the free interaction of minds; in short, the attainment of a *free* community of interpretation. Such a community will not be achieved and preserved unless it is an integral objective of the plan. As Karl Mannheim has pointed out, freedom in a planned society means freedom actually provided within the plan—the provision of mediums for the free expression and interaction of minds and for the democratic "planning" of the planners—the guarantee that the community of interpretation will be free and democratic because it rests upon a community of persuasion. The task is not easy, but upon it depends the hope of the human race.

I began with a note of pessimism. I end with a note of optimism. It seems unlikely that mankind could achieve the magnificent structure of science and yet could so wantonly misdirect it as to destroy the human race. The grandeur of the achievement is an earnest of its proper use. Yet salvation does not come easily, and the burden is laid upon us all.

THE ARGONAUTS

All night the astronomers at their telescopes
Explore the continents of the upper air,
Pursue the Lion down the western slopes,
Or up the east, in Aquila, Altair.
All night they wander on the mountainous moon,
And scale Copernicus or afar descry—
Piercing the blazing, breathless lunar noon—
The rim of Tycho sharp against the sky.

O epic journeys of the eye and mind
Whereon these heroes of our time embark!
They quit this earth and in the zenith find
A Golden Fleece that frees us from the dark:
Searching that center, that atomic core
Which, once controlled, will make us kings, and more!

HAROLD LEWIS COOK

WHERE ARE AMERICA'S RESEARCH RESOURCES?

By ROBERT B. DOWNS
UNIVERSITY OF ILLINOIS LIBRARY

IN HIS report to the President of July 1945, Vannevar Bush, Director of the Office of Scientific Research and Development, states that "adequate technical libraries are an indispensable tool for research workers." The second World War emphasized Dr. Bush's conclusion to a degree never before realized, as scientists drew heavily upon the world's accumulated knowledge to furnish a basis for further research and progress. Scholars in the humanities and the social sciences have, of course, long recognized the fundamental importance of library facilities for their activities. The extent and distribution of American library resources, with which the present discussion is principally concerned, are therefore of vital interest to investigators in every major field.

For background purposes one might first look at library resources in general. Several years ago, in connection with a study of American union catalogs, a detailed statistical analysis was made of world book production from the beginning of printing through 1940. This work supplemented that of M. B. Iwinski, published in 1911. Iwinski calculated that to the end of the year 1908 there were 10,378,365 books in existence. This figure was based upon a careful examination of bibliographical and publication records. Unfortunately, statistics are lacking for certain countries and for certain periods; for example, book production figures for China are unknown. Another difficulty is the lack of agreement between countries as to what constitutes a book. National statistics sometimes include, sometimes omit, pamphlets and other lesser materials. Annual statistics compiled for the United States by the *Publishers' Weekly* are generally considered authoritative but are approximately tripled by the United States Copyright Office's reports. Government publications are excluded from nearly all statistics of national book production, and in most countries, as in our own, the government printing office is by far the largest individual publishing organization.

These facts illustrate the difficulty of arriving at any acceptable figures. Taking the Iwinski estimate as a base, however, LeRoy C. Merritt, an investigator for the union catalog survey, carried the study forward. The determination was reached that the total book production for those countries and those periods for which data are available is 15,377,276 titles. The total is 5,000,000 more than Iwinski counted through 1908, and represents an average annual world book output of 156,000 titles during each of the 32 years from 1908 to 1940. No claim is made for the complete accuracy of these figures, though they are the closest we have. It is astounding to observe that nearly one-third as many books were published in those 32 years as in the previous 450 years.

Assuming that approximately 15 million books can be accepted as the total number printed since the invention of printing, what proportion of the world's literature is now held by American libraries? To ascertain this fact Mr. Merritt sampled the national union catalog in the library of Congress, plus various regional union catalogs and the catalogs of about 100 large individual

libraries. On the basis of the sampling it was estimated there are 10,000,000 separate titles in American libraries, or, in other words, copies of about two-thirds of all books in existence are now available in the United States.

Coming next to distribution, where are the materials for library research in the United States? The distribution is extremely uneven, with the chief concentrations of American library resources to be found in the Northeast, the North-Central West, and the Pacific Southwest. By contrast the Southeast, Southwest, Rocky Mountain area, and Northwest are poorly equipped with research materials. A study of book distribution by states, which I made a decade ago, found the heaviest concentrations of books in New York, California, Massachusetts, and the District of Columbia, in that order, with Ohio, Illinois, and Pennsylvania trailing not far behind. The relative rank has remained unchanged. At the opposite end of the scale, the six states with fewest books are in the sparsely populated Northwest and Southwest, namely, North and South Dakota, Wyoming, Nevada, Idaho, and New Mexico. Near these are three Southern states, Arkansas, Florida, and Mississippi.

Some revealing figures on book distribution were supplied also by Louis R. Wilson. Dean Wilson found that there are 77 centers in the United States which contain, within a 50-mile radius, 500,000 volumes or more. Of these centers, New York, Washington, Boston, and Chicago possess the largest number of volumes. If a map of the United States were divided into four quarters, 57 of the 77 library centers would come within the Northeast quarter. A total of 113,000,000 volumes are concentrated there — about four and one-half times more than the other three quarters combined.

Another approach was made by W. W. Bishop, now Librarian-Emeritus of the University of Michigan. On the basis of their subject holdings, Dr. Bishop concluded that only three major collections of Americana in the form of books are to be found west of the Allegheny Mountains, and only two of the seven leading collections of English literature are outside the Northeast.

Wide publicity has been given by the American Library Association to a situation in which 40 or 50 million people of the United States are without access to public libraries, and another 30 million have inadequate facilities. Much less has been said about the scarcity of materials for advanced study and research in many parts of the country. The fact affects fewer people directly. Nevertheless, it is highly significant from the point of view of the progress and development of those areas. Unfortunately, also, inequalities in the distribution of library resources tend to be perpetuated. Recent figures show that college and university libraries in well-equipped library areas are spending twice as much money, in proportion to population, as the college and university libraries of poorly supplied regions. The gap between the two is therefore widening rather than narrowing—relatively the rich are getting richer and the poor are getting poorer.

A MAJOR aspect of the subject of library resources, and one which deserves separate consideration, is the distribution of materials among different kinds of libraries. The student of American library resources soon becomes aware of the many types of libraries to be found in the United States and of their varying facilities for research purposes.

Standing at the top of our system of libraries, from the point of view of advanced study and research, are the university libraries. The most important and most obvious characteristic of a university, distinguishing it from other educational institutions, is its research

program. Naturally the library of the university is expected to support this program. Using quantitative standards only, 11 American university libraries now hold more than 1,000,000 volumes each. The largest, Harvard, possesses over 4,500,000; the second, Yale, nearly 3,500,000; and Columbia and Illinois contain approximately 2,000,000 volumes each. In addition to these 11 major collections, there are 19 other university libraries with collections ranging from 500,000 to 1,000,000 volumes. Perhaps 20 more have resources that are significant from a research standpoint. In the United States we have, therefore, some 50 university libraries whose collections are of considerable importance to the scholar and research worker.

Closely related to the university library, but of comparatively slight importance for advanced study and investigation, is the college library. Few college libraries have the funds, the incentive, or the need for developing such research materials as are found in the university. Some of them, however, have built up special collections of more than ordinary value. Especially is this true of the New England colleges such as Amherst, Bowdoin, Colby, Dartmouth, Wesleyan, and Wellesley. A few libraries elsewhere—Oberlin in Ohio and Claremont in California, for example—have done likewise. Research resources in collegiate libraries are usually limited, however, to one or two specialized fields, and there are probably not over 10 such institutions in the United States of genuine significance from the scholar's point of view.

Another large group, numerically, are the public libraries, found in every city and town of substantial size in the country. Eight public libraries own over 1,000,000 volumes each, and 16 others run from 500,000 to 1,000,000 volumes. With perhaps two exceptions, these are of far less importance than one would assume from their size. The principal reasons for this fact are that public libraries must serve the needs of large numbers of general readers, who require less specialized material than university professors and graduate students; and, second, the public library must do an excessive amount of duplicating for its branches and to meet the demands of the large clientele served. An instance of the result is the Chicago Public Library, which in 1939 was found to have 1,718,867 volumes representing only 140,000 titles. By comparison, the Ohio State University Library, owning 496,806 volumes—not much more than one-fourth as many as Chicago—had 330,927 titles, more than twice as many. The qualitative difference for research purposes, if measurable, would doubtless have been equally wide.

The two exceptions to the statement about the research importance of public libraries are the New York and Boston public libraries, both quite untypical of the group. The New York Public Library is one of the world's great libraries, holding over 4,000,000 volumes and possessing rich collections in many fields. Similarly, the Boston Public Library has been growing over a long period, is well endowed, and has collections of major importance in a number of divisions. A few other public libraries have outstanding special collections, e.g., the White Folklore Collection in the Cleveland Public Library and the Burton Collection of Midwestern History in the Detroit Public Library. Aside from a limited number of such instances, public library collections are only of local significance.

A fourth group of considerable size are the state libraries. The first state libraries to be established in the United States were those of New Jersey and Pennsylvania in 1796. Subsequently, such libraries have been organized in every state. Many of the states have also set up library extension agencies, legislative reference libraries, state law

or supreme court libraries, state archives, and historical commissions. On the whole, state libraries have not lived up to the high expectations with which they were founded. It has been a common spectacle for them to be regarded as political plums, and, with a few notable exceptions, they have never had the financial or other forms of support necessary for the development of important research collections. The chief types of material of a research nature usually held by state libraries are local newspapers and state public documents. By law, it is the general practice for these libraries to have the exchange privilege for publications of the state government, and they automatically acquire extensive collections of publications of other states. If there is a supreme court library, as is frequently the case, that institution is ordinarily given exchange rights for session laws and court reports, thereby accumulating sizable law collections.

One of the important types of state agency is the organization to preserve archival records, known variously as the state department of archives, state historical commission, or state historical society. This division is given legal responsibility for saving the state's primary records—executive, legislative, and judicial archives, historical manuscripts, and other nonpublished documents. From the viewpoint of state and local history, these collections have assumed increasing importance in recent years. Most of them, unfortunately, do not cover early periods adequately. Among the reasons is neglect: until a generation ago in only a few states was there any genuine interest in preserving archives, and older records were frequently discarded as of no value. Another major cause of destruction has been the numerous fires which have burned down capital buildings in nearly every state, taking with them the accumulated official records. In the Southern states, some older files were lost during the Civil War years.

In summary, the state libraries, state archives, and state law libraries are important for a limited number of fields and types of material, chiefly for newspapers, public documents, law, and local history. They are not significant for research activities of a more comprehensive nature.

A major group of libraries which have grown rapidly in the past generation and are assuming increasing importance in many fields are the libraries associated with the Federal government. Standing at the top of the system, of course, is the Library of Congress, holding notable collections in many subjects, but especially outstanding for the social sciences, history, fine arts, and music. The Library of Congress is now the largest library in the world by a considerable margin. In addition to the national library, which the Library of Congress is for all practical purposes, virtually every government department and bureau has a library of its own pertaining to its specialized interests. Among these are some of the world's leading libraries in their fields: the Army Medical Library contains the largest collection of medical literature in the world; the Office of Education has the largest collection on education; the Department of Agriculture, the largest agricultural collection; the Army War College, the second largest collection on military science; the Geological Survey, the largest geological collection in the United States; the Labor Department, the most complete library in America on labor and social welfare; and there are dozens of other federal libraries of similar rank connected with various branches of the government. Among the reasons for the rapid development of the Federal library system are the generous financial support the libraries have received, their devotion to highly specialized fields, and

their favorable position as part of the national government. In exchanges with foreign countries, for example, the libraries in the governmental organization receive publications, as a rule, before any other institutions in the country.

In addition to the types of libraries named previously, there exists a small but important group usually called "reference libraries," privately endowed and controlled and not ordinarily affiliated with any educational institution. Two of the principal examples are in Chicago: the John Crerar Library, specializing in science, technology, and the social sciences; and the Newberry Library, which is restricted to literature, history, and the arts. Famous examples in the East are the J. Pierpont Morgan Library in New York City, the John Carter Brown Library in Rhode Island, the American Antiquarian Society in Massachusetts, the Folger Shakespeare Library in Washington, and the Peabody Institute in Baltimore. Another great library of the type is the Huntington Library in California, rich in English literature, early printing, and other fields. None of these libraries is large relatively, but from the point of view of the rarity and value of their collections they rank at the top.

A seventh category of libraries which have significant resources for research is a very heterogeneous lot. The term "special libraries" is generally applied to them. One of the largest divisions of this class is the libraries formed in connection with business and industry. Such libraries are usually gathered for the needs of persons actively engaged in the search for information useful in a business, a laboratory, a newspaper, etc. The whole emphasis is on current material and up-to-date information. Consequently, such libraries seldom contain much material of a historical nature, that is, the retrospective or background literature. They are therefore of limited use to the scholar, regardless of the completeness of their files of recent publications. Business and industrial libraries are mainly concentrated, naturally, in highly industrialized areas of the country.

A second large division of special libraries are those owned by societies, associations, and similar organizations. In many cities, for example, bar associations have established law libraries, and medical associations have set up medical libraries for the use of their members. Some of these are among the foremost institutions of their kind; instances are the Association of the Bar of the City of New York, one of the largest law libraries; the New York Medical Academy Library, the second largest medical collection in the United States; and the Engineering Societies Library, maintained by four national engineering societies, one of the country's leading engineering libraries. Hundreds of other examples could be cited, some of only local interest, others of national importance. Ordinarily these collections are highly specialized and are therefore of first-rate value to research workers in the fields covered.

A final group of libraries which possess resources for research are private collections. Some of the most valuable books and manuscripts in the country are in the hands of private collectors. It is extremely difficult, however, to obtain information about them, they are seldom available to outside users, and are constantly changing, being broken up, for example, by auctions, disposal of estates after the deaths of owners, or by transfer to public institutions.

The eight types listed—university, college, public, state, Federal, reference, special, and private—include all the noteworthy research libraries in the United States. Excluding the private collections, whose number is legion, there are at least 12,000 libraries in the first seven

categories. Only a fraction of these, however, can be said to be of national importance for the scholar and research worker. Exactly how many is a debatable point, depending upon the definition used. In my estimation, there are as a maximum, 250 libraries in the country holding collections of more than local or regional significance. Other estimates have generously stretched the number to 500, far too high, and others have stated it to be around 50, probably too low.

Up to this point, an attempt has been made to describe in broad terms the present status of American library resources. What of the future? Can we expect research libraries to continue to develop along traditional lines, or is there a likelihood of radical changes?

When microfilm came into general library use a decade ago, it was predicted by enthusiastic advocates that the new medium would revolutionize library methods, even leading us to discard the book in its orthodox form. Until now, it is hardly necessary to say, the prophecies have not been fulfilled, though microphotography has been accepted by librarians as an important auxiliary tool. More recently Fremont Rider's provocative and stimulating volume on microcards (*The Scholar and the Future of the Research Library.* New York: Hadham Press, 1944) has opened up vast prospects for the utilization of microprint techniques for reproducing and storing research materials. Vannevar Bush carries these ideas a step further by proposing the "memex," placing at the fingertips of the scholar and research worker whole libraries of microfilmed records, made instantly available by indexing mechanisms. The coordinator of American scientists' war efforts believes such a development is entirely feasible.

Less sensational in nature, but considered by many social-minded librarians as providing keys to a number of problems, is another contemporary movement, namely, a wide program of library cooperation. Among the manifestations, some of which have achieved marked success, are: the growth of bibliographical centers in Denver, Philadelphia, and Seattle; establishment of dozens of union catalogs, ranging from local to national levels; the growth of the interlibrary loan system; publication of numerous union lists and other records of library collections; agreements between libraries for dividing fields of collecting, that is, accepting certain fields for specialization; cooperative publishing enterprises, such as issuance of the Library of Congress catalog in book form; surveys of library resources for advanced study and research; plans for regional library development; central storage warehouses, cooperatively maintained by libraries; exchange systems for duplicates and other publications; and cooperative cataloging of material.

Space is lacking here to discuss the library cooperative movement in detail. Such efforts as those listed originated through a widespread interest in increasing the availability of our bibliographical resources, and that is their primary reason for being.

This discussion offers sufficient evidence to show the extent and variety of American library collections. These resources certainly exceed in quantity—and in many respects in quality—those of any other nation. We will continue to fall short of perfection, however, so long as one-third of all books in existence are not represented in the United States, or until we strengthen the research facilities of poorly equipped regions, or until we adopt further measures to speed the research worker's access to his materials. Without being overly optimistic, it can fairly be claimed that progress is being made in all these directions.

MEN, MASTODONS, AND MYTH

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For over a hundred years men have been describing the "coarse brown hair" of the American mastodon, and for over a hundred years the mastodon's hide and hair have been regarded by textbook writers as irrefutable proof of its recent existence. In the midst of this constant repetition of what, through the sheer prestige of age, has come to be accepted as undeniable fact, it has never been pointed out that American institutions of science do not possess the tangible evidence which alone could justify such wholehearted faith in the exact appearance of this long-vanished beast. In addition, it has not been sufficiently noted that the eyes of competent scientists have never beheld this phenomenal spectacle of remains surviving under completely adverse conditions. Furthermore, it has escaped attention that in the one instance in which hair was apparently noted by a reputable scientist that same scientist dismissed it as illusory and satisfactorily explained it.

It is true that some paleontologists have limited themselves to what they regard as a single reliable instance of hair preservation, but it is also true that with the passage of years one or two have quietly dropped the subject from their books. Nevertheless, the story persists and continues to be reprinted down to the present day. It has become, in fact, part of the folklore of paleontological science, flourishing with renewed vigor because of existing archeological interest in the exact time of extinction of the American mastodons.

Extenuating circumstances have admittedly contributed to our gullibility. It is known, for example, that the sloth has left undoubted and unquestioned remains of hide, hair, and bits of cartilage in the insulating dust of the dry American caves. Why, then, should the similar early reports upon the mastodon, long extant in the literature, be questioned? Like my colleagues in paleontology and archeology, I had accepted this impressively documented "fact" until quite recently. Then research on another subject happened to lead me back into the source material of the early nineteenth century. The results of this investigation have completely and thoroughly convinced me that neither "hide nor hair" of the American mastodon has been found under conditions which would justify belief in the authentic nature of such discoveries. Moreover, it is my considered judgment that there exists a completely adequate explanation of these finds—one partially supplied by a paleontologist of note—buried away in the literature and never adequately treated in the light of other, European, discoveries which were agitating the minds of naturalists during this period.

To explore the reasons for assuming this iconoclastic attitude, it will be necessary to examine our subject in minute detail. Perhaps the best method of approach will be to list all those finds where claims are made as to the survival of soft parts, including hair, of the American mastodon. Few would claim validity for all, and, oddly enough, it will appear as our investigation proceeds, that some, at least, of this material was more vigorously questioned in its own day than in modern times.

To pursue certain of these early accounts back into the early nineteenth or late eighteenth century is a tedious and

difficult task. Some, though deriving ultimately from a single source, have been widely scattered through numerous secondary sources from which the accounts have found their way into modern literature. Often the early references are vague, inadequate, or completely lacking. As a result, some detective skill has had to be exerted to discover whether finds reported in two different works actually were distinct discoveries or represented differing accounts of a single early find. The results of these labors, which I think are reasonably complete, have yielded the following items.

Rembrandt Peale, having given an extended account of the excavation of the bones of what we now know to have been a mastodon from a bog near Newburgh, N. Y., goes on to comment: "The only instance of hair being found with the remains of this animal, occurred in a morass belonging to Mr. A. Colden in the neighborhood where this skeleton (the Peale mastodon) was found. The hair was coarse. long and brown, a large mass of it together, and so rotten that, after a few days' exposure to the air, it fell into powder." (This find is sometimes directly ascribed to Peale's mastodon. It should be noted that it is distinct from this find, and that Peale does not claim to have seen the hair in question. Curiously enough, the only other material associated with these remains was a mastodon tooth, according to the account given by Dr. J. G. Graham. It seems strange that this hair, recovered at a depth of four or five feet should have outlasted every other portion of the animal but a single tooth!)

In 1805 Dr. B. S. Barton, writing of bones from Big Bone Lick, quotes from a letter written by John Bartram to James Logan. Bartram's letter gives an account of some "Shawanese" Indians who had brought to Pittsburgh an elephant tooth and a fragment of tusk of which they were attempting to dispose. Describing similar remains, the Indians mentioned a head with a long nose and a mouth on the underside. Though there are no data to show that the Indians specifically mentioned soft parts, this item has been repeated as proof of the survival of fleshy tissue about which the Indians could have known nothing.

In the same journal a year or so later the discovery of mastodon remains in Wythe County, Va., was reported by Barton. The information had been supplied him by Bishop James Madison, at that time president of William and Mary College in Virginia. This find, because of Bishop Madison's prominence, was widely quoted, and numerous lengthy accounts of it are available. One of the best is that to be found in John Godman's *American Natural History*.

In brief, the Bishop claimed, on the authority of gentlemen whose veracity could be relied upon, that amidst the bones of the Wythe mastodon, the stomach, containing a large amount of half-digested food, was discovered in a perfect state of preservation. Neither the bones nor the "stomach" survive. Robert Bakewell, in the first American edition of his *Introduction to Geology* (New Haven. 1829) added mention of flesh to the original version.

Another account, whose exact date I cannot verify, but which has been mentioned by Howorth, Blainville, and Hay, describes the discovery of mastodon remains in Posey County, Ind., in the depths of a sixty-foot well. One of the "curators of the library" at Vincennes, Ind., stated that some skin and hair were found with the specimen.

In 1839 there appeared in the *Philadelphia Presbyterian* of January 12 an account of a mastodon discovery in Missouri. The account was unsigned, but it is known that Albert Koch was the au-

thor. I quote that section pertaining to the soft parts:

> Also between the rocks that had sunk through the ashes was found large pieces of skin, that appeared like fresh tanned sole leather strongly impregnated with the ley from the ashes, and a great many of the sinews and arteries were plain to be seen on the earth and rocks, but in such a state as not to be moved, excepting in small pieces, the size of a hand which are now preserved in spirits.

It may be added that though this animal was later disposed of in Europe, we hear nothing further of arteries, sinews, and hide.

Following this time, fresh accounts of similar discoveries lapse out of the serious literature of science, though the old ones continue to be handed down. Subsequent discoveries of bones were made, but, strangely, hide and hair discoveries are no longer made, the last attempt at that sort of thing being, perhaps, a find at Paw Paw, Ill., recounted in 1914. Here, because of "certain streaks and mossy fibers," the excavators assumed that their specimen (*Elephas columbi*) had been clothed with hair.

Taken together, these accounts present a fairly formidable array of evidence, and it is easy to understand how they have been passed along through the textbooks of science. Yet before beginning our analysis of these discoveries, it would be well to bear the following facts in mind: (*1*) No person of real scientific repute ever saw these remains. At best the accounts have been repeated or retold by scientists. (*2*) The accounts proliferated during a period when the world of science was excited over the discovery of refrigerated remains of the mammoth *Elephas primigenius* in Siberia. This inevitably biased Cuvier, whose works were widely read and quoted both here and abroad, toward the acceptance of such accounts from the New World. (*3*) The stories are old. Though mastodon remains are still found in bog deposits in the Eastern United States, many years have passed since anyone has claimed the discovery of mastodon hair under such peculiar circumstances. This suggests, obviously, that a certain naive credulity and nationalistic enthusiasm have quietly faded out of American biology. A closer analysis will reveal these facts with greater clarity.

In analyzing these early reports it will be well to treat the more easily disposed of discoveries first and reserve the find at Colden's farm till the last. Colden's discovery is early enough to escape the charge of deliberate faking which can be leveled against certain later accounts. Second, it concerns the hair of the mastodon and more or less sets a pattern for later stories. In addition, it is the only find accepted as valid by some writers. If we can show cause for rejecting this particular discovery, the strongest link in the chain of accounts purporting to demonstrate the survival of hide and hair of the American mastodon will have been destroyed. No one has reason to attribute this find to attempts at conscious deception. Its 1800 dating is too early to have been influenced by European accounts of the hairy mammoth. The same cannot be said for certain later discoveries.

Much has been made of the Shawnee Indian account of a head with a long nose. It has been pointed out that the Indians, unacquainted with the Proboscidea in life, would have been incapable of imagining this feature of elephant anatomy unless it had, in reality, been observed in the flesh. (This view has also been expressed in regard to certain Indian legends I have discussed elsewhere.) Actually a perfectly rational explanation on other grounds is possible.

It is to be noted that the Shawnee spoke merely of a long nose. They did not say how long nor did they give any details or even claim it to have been of

fleshy consistency. If one does not allow preconceptions about elephant trunks to obscure the issue but, instead, considers the appearance of both mastodon and mammoth skulls as they would appear to the untutored eye when the tusks had dropped from their sockets, a simple interpretation of the Indian story becomes apparent. If one turns to a good photograph or drawing of the mammoth or mastodon skull as presented, say, in Osborn's *Age of Mammals* or the full-page plate in Warren's *Mastodon Giganteus,* it can be seen that the most reasonable view that one untutored in paleontology could adopt would be that the empty protruding twin tusk sockets overhanging the anterior portion of the mouth were nasal cavities. In comparison with ordinary animals they would constitute, even in the unfleshed skull, a "long nose." No amount of writing can demonstrate this as clearly as a reference to a good anatomical plate.

The Wythe County, Va., find, also recorded by Barton, was challenged and dismissed in its own day by several competent naturalists. Yet, perhaps because the details were supplied by a churchman of high standing and because corrections of error never receive as wide publicity as the original statements, this find is still occasionally referred to as valid.

Whether or not the account of the contents of the animal's stomach as being present is true need not concern us greatly. Twigs and similar plant remains may survive for long periods under bog conditions. In the light of the general inaccuracies accompanying the account, however, it is by no means unlikely that even this item is the result of misinterpretation of materials in the stratum where the animal lay. Our real concern is with the report that the stomach itself was present. Considering the fact that all the other soft parts had vanished—cartilage, hair, and hide—this preservation of so delicate an organ as the stomach ceases to be merely possible; it takes on an aspect of the miraculous. Nor was it long before the discovery was challenged.

A very competent and astute, though anonymous, reviewer treated the whole subject with vigor and thoroughness during the course of a review of the first American edition of Robert Bakewell's *Introduction to Geology.* Bakewell had collected and repeated in a rather uncritical fashion, stories of the type we have been examining. Some were obtained from Cuvier's *Ossemens Fossiles,* Cuvier himself being also somewhat credulous about items received from far-away America. Portions of this anonymous review are worth reproducing here:

> . . . we should not any the sooner believe that this was a stomach and that its possessor died in the act of digesting its food; still less that it belonged to the mastodon itself whose bones lay around. The idea of the stomach enduring the destroying action of long inhumation, which no other parts except the bones could withstand, not even the integument, cartilage nor tendon seems really too ridiculous to have ever been seriously related. . . .
>
> We are sorry to see such things in a work of this kind, many of the readers of which may be incapable of investigating the subjects themselves, and the wrong impressions which they get may not soon be corrected. We know not how it is, but really, naturalists over sea have the luck of knowing a great deal about the mastodon that we never dreamt of here.

Even prior to this critique, however, Dr. John Godman had given an extended account of the Wythe County find and recorded the fact that Bishop Madison later tried to correct the impression made by his ealier statement "acknowledging that his information was inaccurate, and his conclusions too hastily adopted." The find was also dismissed by James Hall, the great nineteenth-century geologist, as "altogether fabulous." Since, in spite of refutations, the story continues to float through the literature, let us finally reiterate: the supposed stomach does not survive; the bishop

who had the story from gentlemen who remain anonymous "recanted" from his previous position. Probably it is through the medium of *Ossemens Fossiles,* which ran through several editions, that certain of these stories have gained such currency in scientific circles that there is a continued tendency to accept them, with scant realization that they were challenged successfully even in their own day.

BEFORE passing on to a discussion of the remaining finds, note should be made of factors which, both here and abroad, were contributing to a more credulous attitude on the part of public and scientists alike toward the sort of discoveries we have been discussing. The discovery of fossil elephants in the New World had greatly stimulated the birth throes of the young science of paleontology. A cluster of great names—Buffon, Cuvier, Jefferson—had focused attention upon the subject. Collections of fossil bones were gathered up, exhibited in private museums for a fee, and then taken abroad for exploitation. The great public museum of today did not exist. To maintain interest, the owners of such collections did not hesitate to embellish their more exciting specimens by appropriate and judicious use of items that would lend human interest. It is in such a light that we have to consider the discoveries and publications of such men as Albert Koch.

A find which immensely stimulated popular interest in fossil elephants and played directly into the hands of some of the less scrupulous collectors in America was the discovery of refrigerated mammoth remains in Siberia in 1799. There are earlier accounts of such remains in the literature, but this was the first find actually to reach a museum. Many pounds of hair were obtained which eventually reached a number of the European institutions. The first accounts appeared in 1807, and thereafter the news was widely disseminated and soon known in France, England, and America. A precedent had been established—a precedent for the discovery of elephant hide and hair in the New World. Moreover, the European scholars, such as Cuvier, were more inclined as a consequence to credit these tales when they appeared in a New World setting. The American Barnums who lived upon public interest were quick to see that such discoveries of hide and hair were a great stimulant to the popular imagination. It is in this light that we must consider the activities of Albert Koch. He was a public showman, and in spite of one or two attempts to clothe him in the tatters of scientific regalia, his career is not such as to justify confidence in his word upon the more spectacular phenomena of paleontology. There is more than a little imaginative literary flair in the account of "sinews and arteries . . . plain to be seen on the earth and rocks, but in such a state as not to be moved. . . ."

George Gaylord Simpson, who has made the most intensive study in existence of the beginnings of vertebrate paleontology in America, dismisses Koch with the incisive comment: "Koch's data and publications have little scientific value and hardly merit mention . . . unless possibly as comic relief." He is similarly castigated by Digby. The bones secured by Koch at his sites were exhibited in Europe in 1842 and later sold to European museums. Perhaps the best commentary on the whole affair lies in the fact that though the European museums had eagerly acquired mammoth hair from Siberia and would doubtless have been similarly anxious to acquire Koch's specimens, "preserved in spirits," we hear no more of the arteries, sinews, and skin fragments. They were the evanescent products of imagination —no more—yet Koch's appetite for such

creations is transparently indicative of the journalistic tastes of a vanished era.

The minor items which remain to be considered before turning back to the discovery on Colden's farm are not of a significant character. The find at Posey, Ind., of mastodon hide and hair in the depths of a sixty-foot well, the details vaguely given on the authority of "one of the curators of the library," has about the validity of common gossip. The material is not preserved, and it has been noted by the paleontologist Hay that a well of the depth given would in that region carry the remains into Iowan loess or Wisconsin drift, depending upon the location. This can be then, no argument for recency, but even under geological conditions of a more modern order, this vague tale, incapable of substantiation, is scarcely worth the effort to refute.

The 1914 discovery at Paw Paw, Ill., is obviously a case of confusing moss with hair—something any untutored excavator is apt to do.

We come now to the most important discovery of all—the find on Colden's farm. This discovery has been thought to answer requirements not met by the other more obscure and questionable tales. Alexander Colden was a simple farmer, not a showman like Koch. His discovery was reported by a gentleman country doctor with only the purest of scientific motives at heart—a man who stood to gain nothing by his account and who immediately lapses back again into rural obscurity, leaving no line in the histories of science. Yet he says: "In Orange County near Montgomery, New York a tooth (one of the grinders) and some hair, about three inches long were found by Mr. Alexander Colden four or five feet below the surface."

Dr. James Graham wrote these lines in 1800. He did not know of the discovery of frozen mammoth remains in Siberia. Yet he and Peale speak of the coarse brown hair which is later to grow so common in the literature and be described as dun-colored. Their reports are not to be dismissed as in the case of Koch. These men saw something, found something. On this point hinges the whole defense for the complete recency of the American mastodon. What was it that lay in the gloomy peat swamps of the New York woodlands which, when found, set men to talking of a beast vanished so recently he might almost have seen the Puritans land? It was, of course, hair—hair of the mastodon—the hair that is pictured in every restoration on museum walls. From that day to this no one has been able seriously to challenge the existence of that hair—no one, that is, but one man. He found the answer and promptly buried it again in the depths of a huge geological report.

James Hall was one of the first really scientific geologists America produced. He was an authority on the Paleozoic System of North America and probably one of the first men in America really experienced enough to pass an objective judgment on that queer brown hair from the backwood swamps. In a huge volume on the geology of New York State Hall ventured, in his typically restrained and quiet manner, a comment on a site of similar implications. In 1843 he wrote:

> In a small muck swamp in Stafford, Genesee County, a small molar tooth was found several years since. Its situation was beneath the muck, and upon a deposit of clay and sand. A large quantity of hair-like confervae, of a dun brown color, occurs in this locality; and so much does it resemble hair, that a close examination is required to satisfy one's self of its true nature.

The circumstances of this discovery are remarkably like those of a half-century before on Colden's farm. A solitary tooth is the only mastodon evidence; the entire body has disappeared, yet the hair remains. Furthermore, here again

is the dun-brown color. But this time a careful, trained scholar looks at it closely. It is confervae—stringy tough strands of algae from the New York swamps, and algae with a tendency to turn dun brown!

If James Hall had written out a discussion of the whole problem, it is probable we would not be arguing this point today. Hall, however, was engaged on weightier tasks. He had the whole geology of New York State on his hands. He recorded his own particular site and he settled its position in the literature once for all—it was never listed as another hair discovery! But once that was done, he forgot it in the immensities of his many volumes. He never turned to the subject again. He never discussed Colden's discovery. But Colden's find, through the medium of Dr. Graham's words, continues to pass down through the literature.

One other faint bit of light flickers upon Colden's swamp for a moment and aids in substantiating the judgment derived from Hall. Godman gives an account of a mastodon find in Orange County, N. Y., in 1817. The bones were found four feet below the surface of the peat, surrounded with "coarse vegetable stems and . . . broken films of confervae, like those of the Atlantic shore."

Professor S. L. Mitchell, the geologist, explored the site, recognized the confervae. The statement is made that the site had been worked some ten or more years previously. This would carry its dating approximately into the time the Colden farm discovery was made. It is possible that the site represented is the same. But at any rate we have brought into the very neighborhood of Colden's discovery, the demonstrated existence of filamentous confervae and shown it to be present at the levels from which the Colden discovery came. Alexander Colden, farmer, and James Graham, physician, were mistaken in what they thought was mastodon hair. But mistaken with them have been a large number of later scientists of better training who, partly influenced by Siberian discoveries, had come to accept the idea that finds of this sort might naturally be expected. The anatomist Warren, for example, is found using the Russian material as evidence that hair can be preserved in America. He skirts, however, the difference in latitude involved.

There remains, then, from all the spectacular stories of the hide and flesh of the American mastodon only a faint swamp effluvium, perhaps a hint of lingering bone marrow or the organic matter of the bones themselves in the encasing muck of ancient bogs. And even these faint smells are probably more suggestive of the general organic composition of the muck itself than of the bones. Nevertheless, we may record this type of organic survival as possible. But whatever the antiquity of the American mastodon, it is safe to say that "nor hide nor hair" of him remains. We assume that he may have been clothed with hair like his brother, the mammoth, but the dun brown in which he has masqueraded these many years is that of drying algae. It is not the coat of the vanished mastodon, nor does it prove his near-colonial survival.

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IMPROBABILITY

One ultramicrocosmic mote of dust
Among unnumbered cosmic galaxies
And one colloidal spawn from ancient seas,
One transient form from millions upward thrust
To last a twink, then sink into the crust
Of earth inanimate: what phantasies,
What paranoid and crass audacities,
For this minuscule midge to feel he must

Somehow endure, be central to some Plan,
The End for which the macrocosmic Whole
Was made . . . Dreamer and dunce, thy name is Man!
Life on the stars?—a doubtful guess, a droll
Desire; life after death?—a dubious hope
Born in the dark where humans blindly grope.

READ BAIN, 1946.

RESEARCH ON AGRICULTURAL PRODUCTS[1]

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AGRICULTURE in the broad sense may be defined as the science and art of producing plants and animals—that is, living systems—including vegetables, fruits, cereals, animals, and fiber crops. In other words, we are dealing with complete biological entities produced as a result of the intricate vital processes of reproduction and growth. When we conduct research on any phase of agriculture we are dealing with the phenomena of complicated living systems. Particularly when we attempt, by research, to understand and modify those systems and to adapt them to economic uses do we find their physical and chemical characteristics both interesting and complex.

Two examples of research in the Western Regional Laboratory will serve to illustrate the use of basic knowledge in the scientist's attempt to make something new and useful. I will first outline as briefly as possible the theoretical aspects of the work in each case and then show how the fundamental facts and theories are applied in a practical manner. One example is essentially biochemical; the other is essentially biophysical. The material for the former was supplied by H. P. Lundgren and for the latter by T. M. Shaw, who are engaged in research in those respective fields in the Western Regional Research Laboratory.

Approach to New Protein Fibers. The first example is concerned with one phase of our work on proteins, the chief objective of which is the production of fibers. Proteins are nitrogenous organic compounds with large, complex molecules. They are found in both vegetable and animal matter. Structurally, they belong to the important class of substances whose molecules consist of long chains formed by the union of certain atoms in amino acids; the result is a backbone structure of carbon and nitrogen atoms, to which amino acid residues are attached as side chains. These chains have two important properties. First, since atoms can rotate around single bonds, the chains can curl and fold up into a wide variety of configurations, and, second, since active groups are present on the side chains, the chains can interact. Such interaction can occur between segments of the same chain and between different chains. These properties, according to present theory, determine the state in which proteins are found in natural substances. For example, the chains may be held folded in the form of small corpuscles, as in the vegetable, egg, and blood proteins, or they may be found in extended forms, as in feathers, hides, hoofs, horns, wool, and silk. Now if it is possible to liberate these chains from their natural confinements and to preserve, of course, their long-chain structure, it may be possible to reconstruct them into fibers and films having desirable physical properties.

The properties of curling and interaction of chains are of practical importance and constitute the basis of the essential physical properties of rubbers, films, fibers, and plastics. Figure 1 shows a comparison of three types of long chains: the rubber chains, built up of units called isoprene units; the chains in

[1] Presented before the Utah State Chapter of Sigma Xi, March 1945.

[2] Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture.

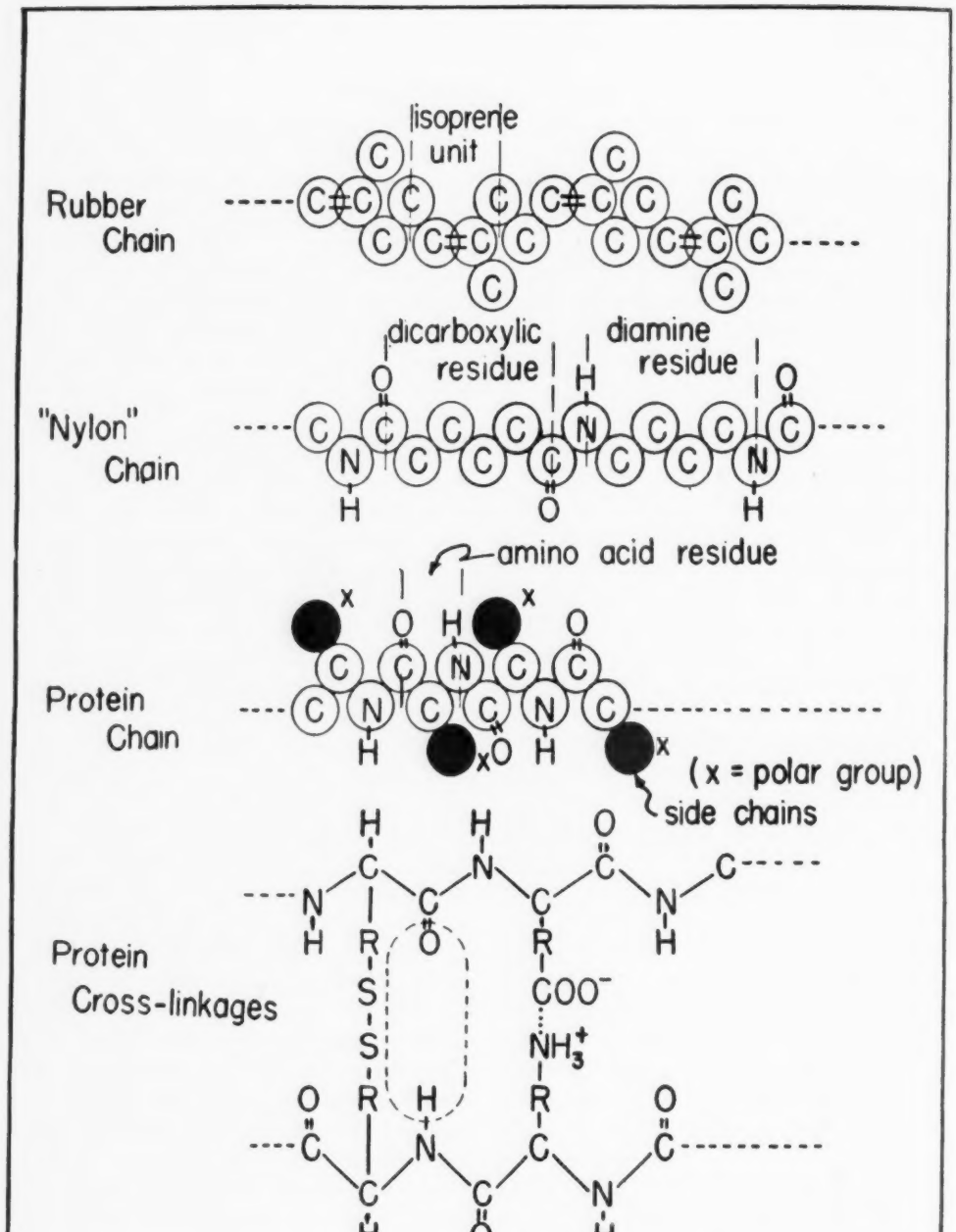

FIG. 1. THREE TYPES OF MOLECULAR CHAINS

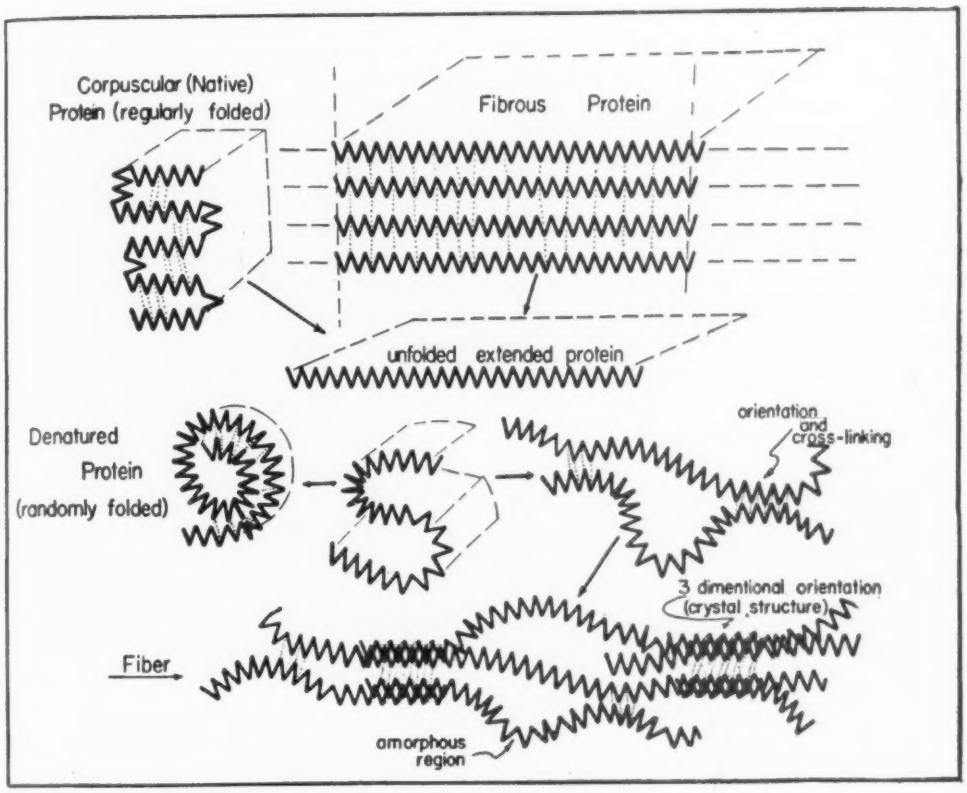

FIG. 2. THEORY OF REORIENTATION OF CHAINS

nylon, made by condensation of dibasic acids with diamines; and the protein chains, built from amino acids. Because the chains of soft rubber lack the ability to form inflexible unions, the material exhibits a high degree of flexibility—that is, curling and uncurling. When sulfur is introduced by the process commonly known as vulcanization, the chains become firmly tied together until, with sufficient sulfur, a hornlike plastic, or "hard rubber," is obtained. The proteins, too, contain sulfur, which in horn, hoof, feathers, and wool serves to tie the chains firmly together. Another type of linkage that may occur between chains is the so-called hydrogen bond, which is responsible for the strength of nylon and also that of rayon and cotton and seems to occur to a certain extent in the proteins. The so-called salt linkage occurs in proteins because there are both acidic and basic groups on the side chains along the backbone structure.

Information such as this is the basis for all fundamental work. In other words, the more detailed the information we have about a given material, the better are our chances of discovering new uses for it. As we have seen, the long-chain molecules form the basis for the essential physical properties of rubber, films, fibers, and plastics. Figure 2 suggests the structural transformations involved in the making of synthetic fibers from proteins. The main object is to liberate the chains from their natural confinements and to reconstruct them in endless chains tied together by strong crosslinks. With a corpuscular protein

as starting material, it is first necessary to break the bonds holding it in the folded configuration; with the fibrous proteins, such as feathers, the chains are already in an extended state and are held in three-dimensional networks. Obviously, any method of dispersion that involves the use of such agents as strong acids or bases must be avoided; if such agents were used, the chains might become degraded, and the ultimate properties of the fibers would be weakened.

The first step in the modification of a protein is its dispersion—that is, separation of its molecular chains in a solution. From there on, the process of making the fiber is essentially a duplication of the process used by the silkworm. The silk in the caterpillar is in the form of a viscous solution, consisting of the free protein chains. Upon extrusion through the small spinneret openings of the worm, the material congeals, the chains interact, and the fiber becomes at first highly elastic and rubber-like. The worm stretches the fiber as it spins, and the result is an alignment of the chain molecules, with further interaction. X-ray measurements show that the molecular chains in the fiber are aligned in the direction of the fiber axis; this condition permits maximum interaction of chains and high strength.

Various attempts to make fibers from proteins have been made during the past fifty years, some of which have succeeded within rather narrow limitations. Most of these attempts have been based on the solubility of proteins in alkalies and their insolubility in acids. Commercial casein and soybean fibers are now made by a procedure based on this fact, but they lack the strength of natural protein fibers such as wool and silk. Either the molecular chains in these proteins are not long enough, or else they become degraded in the procedure used in their manipulation.

Another approach to the making of fibers from protein is being studied at our laboratory. This method involves the use of special agents that are mild and that react with the protein to form a complex that is readily manipulated from a viscous solution to a rubber-like state and then to a fiber. Finally the agent is recovered, leaving the chains aligned in the direction of their length.

Agents that have been found most effective in our laboratory are certain synthetic detergents (widely used as cleansing solvents). Synthetic detergents are in general excellent solvents for protein. They will disperse feathers, wool, and hair in the presence of reducing agents (which prevent oxidation) and will disperse and unfold corpuscular proteins. Highly technical studies have shown that they form what we call "complexes" with the protein. These complexes form by virtue of the fact that all proteins have free basic and acidic groups along the chains which can react with an anionic or a cationic detergent to form salts. Accordingly, the first stage in the reaction between protein and detergent is stoichiometric; that is, the reaction involves one detergent ion for each basic or acidic group of the protein. When the stoichiometric reaction is complete, additional detergent ions can be attached along the unfolded protein chain. Under such conditions and in the presence of water, the protein chains can slip past one another easily. These complexes are readily precipitable by the use of salt, and the result is a rubber-like precipitate that can be stretched into a fiber. The spinning and stretching cause the alignment of the chains that is characteristic of natural fibers. Following this step, the detergent can be recovered with acetone.

This outline of the procedure which our protein chemists have developed shows that we do approach practical problems through knowledge of fundamental properties of our materials.

From information gained through the use of highly specialized physical and chemical techniques, we are approaching the time when it will be possible to predict whether or not a protein, or for that matter any other long-chain system, will be suitable as a raw material for fibers, plastics, rubber, or films.

Recent developments in long-chain chemistry have opened new vistas to the scientific mind; new fibers, which vary widely and have many useful properties, are within the range of possibility. We need only to look, for example, at rayon and nylon to see the possibilities that exist when appropriate means are available for the manipulation of long-chain molecules. We have rayon, nylon, vinyon, and glass fibers, but each has its own characteristic properties. Similarly, we have the natural fibers—each well adapted to certain uses. And we are attracted by the possibility of the discovery of artificial protein fibers that have new and special properties not found in any other fibers.

Theory of Dielectric Constants. The next example is concerned with a problem in biophysics, and it involves the theory of dielectric constants. Industrial research leans heavily on modern physics for new methods and tools in research. Among the more prominent physical tools the X-ray diffraction camera, the spectroscope, and the dielectric cell may be listed. The numerous applications of the X-ray camera and the spectroscope are widely known. The dielectric cell is not, however, so well known, and I shall review very briefly its theory and discuss some of its contributions and potential uses. The dielectric cell becomes an old friend of most of us when introduced by its more common name "condenser." Benjamin Franklin's famous Leyden jar of the lightning experiment was one of the earliest forms of condenser, or dielectric cell. In Figure 3 a Leyden jar is compared with a modern dielectric cell for liquid dielectrics. Both condensers contain the same basic elements, namely, two conductors and an insulating material called the "dielectric." Both cells store electrical energy, and this property, known as "capacitance," can easily be demonstrated by a simple experiment: first, we can charge the condenser by connecting the conductors to a battery; and, second, upon removal of the battery and short-circuiting the conductors, we can draw an electrical spark.

The importance to us of the dielectric cell is illustrated by an experimental observation of Michael Faraday (1791–1867). Faraday studied the variation in capacitance of a spherical condenser, consisting of two concentric spheres, when different substances were used to fill the space between the spheres. He found that all so-called insulating substances, or "dielectrics," gave the condenser a greater energy-storing capacity than it had when only air separated the conductors. This ability of a substance to enhance the capacity of a condenser is a fundamental property of matter, which we call the dielectric constant. Its magnitude varies from slightly more than 1 for gases to 80 for water and even larger values for certain mixtures.

Faraday explained the action of dielectrics in increasing capacity by assuming the presence of elementary electrical particles in the dielectrics which, although uncharged on the whole, had separate and opposite charges on the two ends. These particles, he said, might be created by the action of an electric force on neutral particles or they might result from some electrical peculiarity of the molecular structure. In the past 30 years physicists have shown that Faraday was right. Today we speak of induced and permanent dipoles, in correspondence with the two types of electrical particle assumed by Faraday.

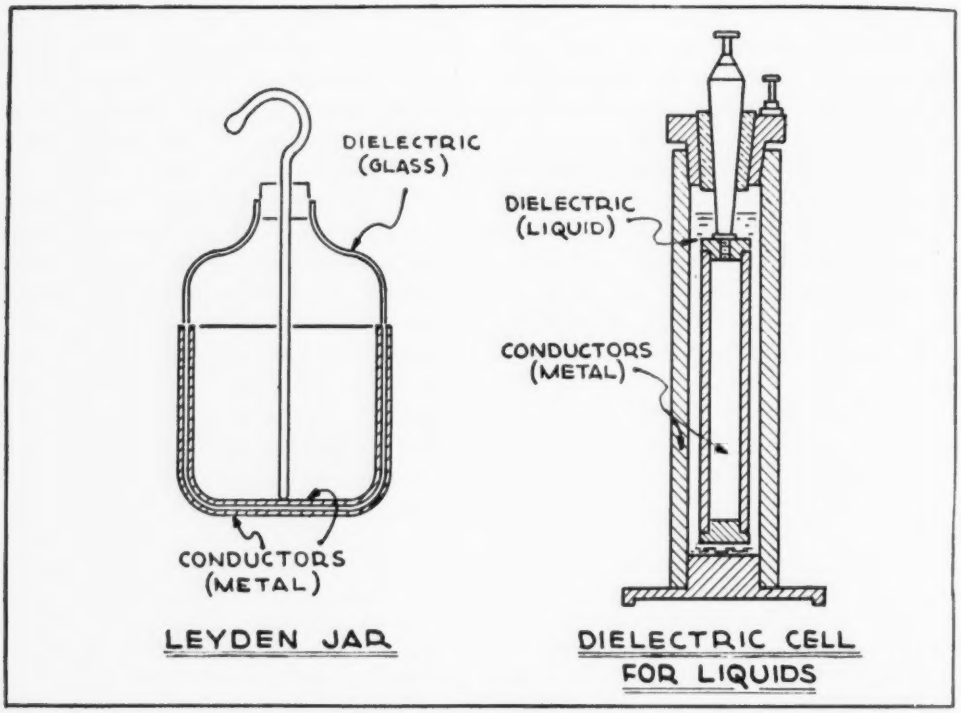

FIG. 3. A LEYDEN JAR AND A DIELECTRIC CELL FOR LIQUIDS

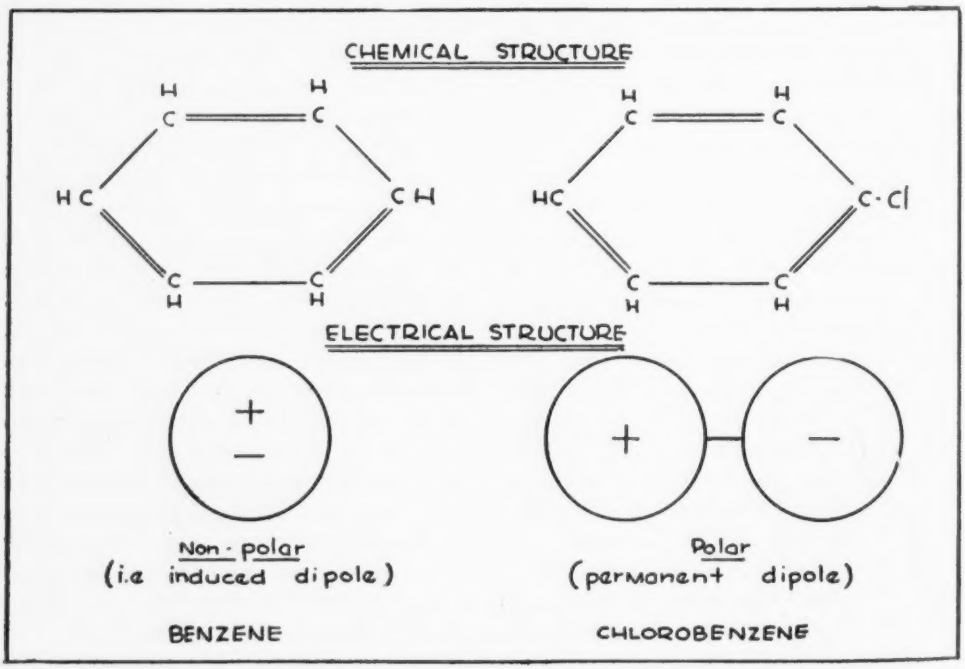

FIG. 4. EXAMPLES OF INDUCED AND PERMANENT DIPOLES

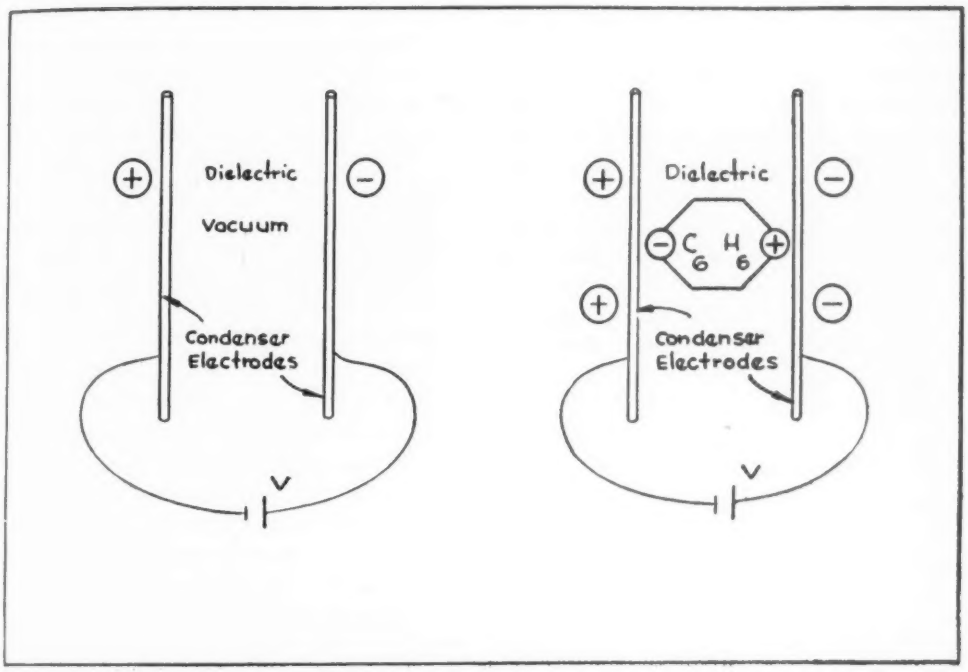

FIG. 5. WHY DIPOLES INCREASE CAPACITANCE

A schematic drawing of two typical electrical dipoles, benzene and chlorobenzene, is shown in Figure 4. Benzene is typical of so-called induced dipoles, or dipoles that exist only in the presence of an electric force. Such materials are electrically neutral until, in the presence of an electric field, the symmetrical distribution of positive and negative charges within the particle becomes disturbed and an induced dipole is formed. Chlorobenzene is typical of so-called permanent dipoles. Materials such as this are permanently unbalanced electrically, because the centers of population of the positive and negative charges in the molecule do not coincide.

The manner in which dipoles increase the capacitance of a condenser is illustrated in Figure 5, in which a condenser is shown at the left with one dielectric (vacuum) and at the right with another (benzene). We will assume that when the dielectric is vacuum the condenser is of such dimensions that one plus charge and one minus charge on the conductors is sufficient to charge the condenser to a given electrical potential in accordance with the relationship $C = Q/V$, where C is the capacitance, Q is the charge, and V is the potential.

Now consider the same condenser when benzene is the dielectric. Benzene, we know, has a dielectric constant of slightly more than 2, compared to a vacuum. Hence, the ability of a benzene-filled condenser to store electrical charges must be about twice that of the condenser with vacuum as the dielectric. As the illustration shows, this ability arises from the fact that the charges on the induced dipoles in the benzene effectively neutralize some of the charge on the condenser electrodes. As a result, the battery must furnish more charges to the electrodes in order to supply the excess of one plus and one minus charge, which we assumed were required to maintain the potential V.

Entirely similar considerations apply

to materials containing permanent dipoles, like chlorobenzene. In the absence of an electrical potential, the chlorobenzene is electrically neutral. Thermal motion of the dipoles causes a random distribution of the positively and negatively charged ends of the molecule, so that on the average the dielectric is uncharged. When an electrical potential is applied, however, the random distribution is disturbed and the charges on the dipoles of the dielectric effectively neutralize some of the charges on the condenser electrodes. This results in the battery being forced to supply more charges to the condenser electrodes, in order to raise the potential to the given level V. Experiment shows the dielectric constant of chlorobenzene to be about 5.

It is obvious that the large differences in dielectric constant resulting from substitution of the atomic groups in organic compounds, such as we have considered, furnish the experimenter with a valuable means of detecting changes in molecular structure and of characterizing known structures. Much work of this character has been done, and today the dielectric constants of many compounds are known with such certainty that they can be used as one of the most sensitive means of establishing the identity and purity of chemical compounds. For illustration, the dielectric constants of a few well-known compounds are shown in Table 1.

TABLE 1

DIELECTRIC CONSTANTS OF TYPICAL ORGANIC COMPOUNDS (AT 20° C.)

Benzene	2.28
Carbon tetrachloride	2.30
Pentane	1.85
Hexane	1.89
Ethyl ether	4.40
Acetone	21.3
Ethyl alcohol	23.8
Methyl alcohol	34.0
Water	80.0

TABLE 2

DIELECTRIC CONSTANT INCREMENTS OF TYPICAL PROTEINS

	Dielectric increment	Molecular weight
Gliadin	0.15	42,000
Zein	0.45	39,000
Secalin	1.0	24,000
Egg albumen	0.17	34,000
Lactoglobulin	1.5	40,000

The value of dielectric constants in characterizing molecules is not limited to low-molecular-weight compounds. Indeed, it has played a conspicuous part in the study of high-molecular-weight compounds, particularly the proteins. For example, consider Table 2, which shows the dielectric constant increments of several typical proteins of agricultural interest. (We speak here of the "dielectric constant increment" rather than the "dielectric constant" because these materials are practically always studied in solution. The dielectric constant increment is defined as the change in the dielectric constant of the solution per gram of dissolved protein.) As the data clearly show, the dielectric increments provide one means of differentiating compounds of practically identical molecular weight.

A serious handicap to the extension of dielectric measurements to proteins and other materials of like nature of agricultural interest is the requirement that the conductivity of the system studied be very low, of the order of that of distilled water. This requirement has seriously hampered the use of dielectric measurements in many important problems. At the Western Regional Research Laboratory our men have made some progress in the removal of this limitation. Measurements of the dielectric properties of an aqueous solution of a protein have been made in which the concentration of protein was about ten times

greater than had been previously reported.

By working at this high concentration (10 percent), our men have found that the electrical properties of a protein solution change very greatly as the concentration is increased. These results suggest the use of dielectric-constant measurements in studies of the interactions of various proteins in solution.

Applications of Dielectric Principles. Water is an important constituent of all agricultural materials. The removal of this water from vegetables and fruits constituted a very great problem in our war effort. But along with the problem of removal of water goes the difficult problem of assaying its quantity in these materials. The emphasis placed on dehydration by the war again brought the problem of determining "moisture content" to the attention of research workers, and hundreds of technical publications prove the problem to be of long-standing importance. Literally dozens of methods have been developed. Only one of these, however, can claim distinct advantages in speed and nondestructiveness; that one is the so-called dielectric-constant method.

Briefly, the dielectric method consists in placing a sample in a condenser and measuring its dielectric constant. The determination is usually carried out at room temperature and involves no alteration of the sample. By reference of the value obtained to a calibration curve of moisture content versus dielectric constant, the moisture content of the unknown is obtained.

This method is not new, but it has undergone considerable development recently because of the demands of the dehydration industry for a rapid method of determining moisture content. At the Western Regional Research Laboratory the application of the method to dehydrated carrots, cabbage, and potatoes has been studied. Not only have several commercial types of dielectric moisture testers been evaluated, but a great deal of effort has been expended in obtaining fundamental information on the effects of the various factors that enter into the determination of the dielectric constant of dehydrated materials; for example, temperature, particle size, and density of compaction of sample.

The method developed at the Western Regional Research Laboratory employs the dielectric cell shown in Figure 6. This cell is very convenient to use and requires only 40 grams of sample, which can be used for other purposes since it is not altered during the measurements. It is designed especially for ease in filling and to exclude from the measurements all stray electrical influences. Circulation of water through the external coil brings the contents of the cell to a definite temperature in a short time. Routine measurements can be obtained in about 20 minutes. With slight sacrifice in accuracy, the time required can be reduced to about 5 minutes.

A calibration curve for carrots is shown in Figure 7. This curve was established with samples containing amounts of water determined by the vacuum-oven method. After the curve is established, it can be used in all work with similar carrots. The precision of the calibration is such that the moisture content can be determined to within plus or minus 0.1 percent over the moisture-content range of 2 to 8 percent, which is the range of moisture particularly important in dehydration practice. If the need arises, calibration curves can be extended to about 20 percent water.

The principal disadvantage in the dielectric method is the requirement of a calibration curve, and someday this disadvantage may be removed if our knowledge of dielectric constants advances to the stage where that of a mixture can be calculated from a knowledge of its chemi-

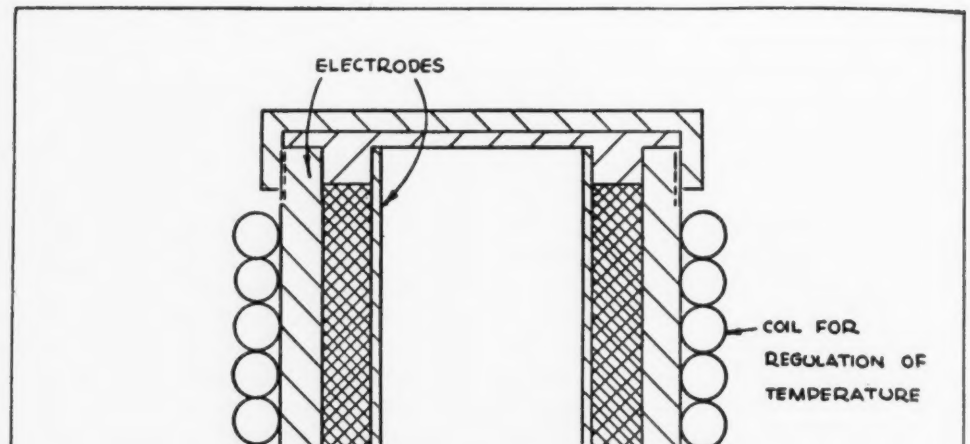

FIG. 6. A SPECIAL DIELECTRIC CELL
USED IN LABORATORY RESEARCH TO MEASURE THE MOISTURE CONTENT OF DEHYDRATED VEGETABLES.

cal composition and physical state. Meanwhile the method offers the conspicuous advantage of speed.

Another application of the dielectric

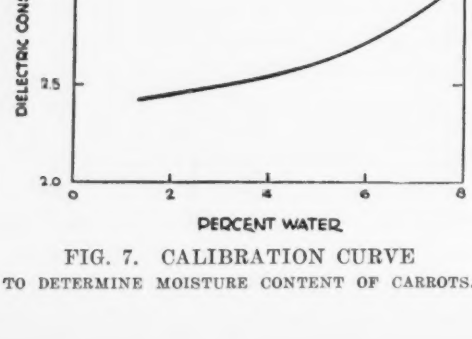

FIG. 7. CALIBRATION CURVE
TO DETERMINE MOISTURE CONTENT OF CARROTS.

cell is one that is currently receiving a large amount of publicity. I refer to so-called dielectric heating, sometimes referred to as high-frequency heating. Dielectric heating is particularly applicable to materials classified as poor conductors of electricity, and into this class agricultural materials fall readily.

Probably the most successful application of dielectric heating is the heating of plywood. In the manufacture of plywood it is necessary to raise the temperature of the wood adjacent to the glue as well as the glue itself to about 275° F. With steam-heated presses it is necessary to heat the entire thickness of wood to the gluing temperature, a process requiring about nine hours, even for rela-

tively small thicknesses of six inches. Today, by the use of dielectric heating, it is possible to glue sections of wood up to many feet in thickness. The time required to heat the glue and the adjacent wood in a six-inch-thick piece has been reduced to about four minutes instead of nine hours, principally because with dielectric heating the heat is generated where it is wanted and it is no longer necessary to conduct the heat required at the glue line through the entire wood mass.

Dielectric heating is directly related to certain characteristics of the dielectric particles to which I referred earlier. When an electric force is applied to a dielectric, the elementary particles of the dielectric are disturbed. When the force is removed, the particles tend to regain their former positions. The important point is that in this process, energy is dissipated as heat within the dielectric. By periodic application of an electric force to the dielectric, the rate of energy dissipation may become sufficiently great to be of practical value.

Dielectric heating has been applied to various problems at the Western Regional Research Laboratory. I shall mention only two applications, one to dehydration practice, and another to the thawing of precooked frozen foods. It was found that dehydrated potatoes could not be successfully compressed into blocks at the specification moisture content of 7 percent. Good compressed blocks could be produced, however, when the potatoes contained 15 percent water. However, the final drying of the compressed blocks by conventional methods from 15 to 7 percent or lower was extremely slow because of the time required for heat to flow from the surface of the block to the interior and because of the length of path of moisture movement. For this reason a test was made of dielectric heating; that is, the heat required for drying was developed in the potatoes. Potato blocks were dried in a vacuum oven and also in a special vacuum oven with dielectric heating. The results of some of the tests are shown in Figure 8.

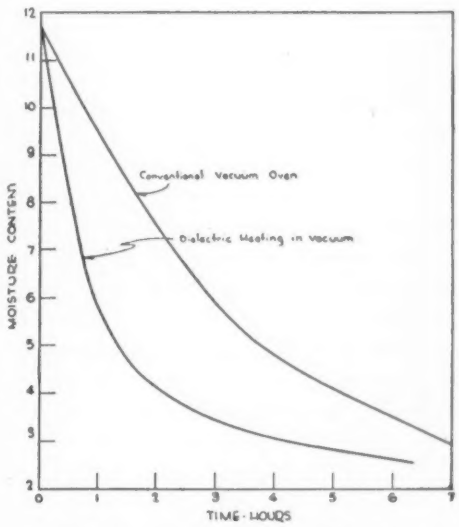

FIG. 8. DRYING POTATOES
REDUCTION OF MOISTURE CONTENT IN BLOCK OF DRIED POTATOES BY TWO TYPES OF HEATING.

The data show that the dielectric heating resulted in a much greater *initial* rate of drying. As the samples became drier the disparity in the rates shown by the two methods decreased because, once the potato blocks reach the desired temperature, rate of diffusion of water from the blocks is the factor that determines the drying rate. With dielectric heating, no problem of heat transfer entered; the samples could be brought to the desired temperature almost instantaneously. In the conventional vacuum oven, however, considerable time is required for heat to be transferred from the oven throughout the sample.

Potatoes dried by the dielectric heating process did not have as good quality, however, as when the slower vacuum oven was used. Apparently a low temperature is desirable at the beginning of the drying cycle when the moisture content is relatively high. While the dielec-

tric heating cycle could be altered to suit this condition, much of its advantage of speed over the conventional vacuum oven would be lost. Obviously, however, in those instances where the material to be dried is not so subject to heat damage as potatoes, the dielectric method offers a possible advantage in speed of drying.

The second application of dielectric heating I wish to consider concerns the thawing of frozen foods, particularly precooked food. In order to increase the usefulness of frozen foods it appears necessary to devise some means of thawing the material and raising its temperature to approximately room temperature in a matter of minutes, rather than hours, as is now required. The present discussion concerns both home and industrial consumers, being equally important for the small packages of frozen food used in homes and the much larger packages held in storage for further processing. The home consumer is primarily concerned with the question of speed, and the industrial processor is principally concerned with the prevention of changes in quality that occur when frozen foods are held for long periods in thawing rooms.

Conventional thawing procedures never result in the entire mass of food being thawed simultaneously. Some portions of the package thaw quickly and are subject to detrimental changes during the period required by the remainder of the package. At the Western Regional Research Laboratory experiments have been conducted to determine whether dielectric heating can be applied to this problem. These experiments have been conducted on standard one-pound packages of frozen fruits and vegetables. The entire package, about $2 \times 4 \times 5\frac{1}{2}$ inches in size, complete in its original cardboard wrapper, was placed between flat parallel copper plates, which formed the dielectric heating-cell electrodes and

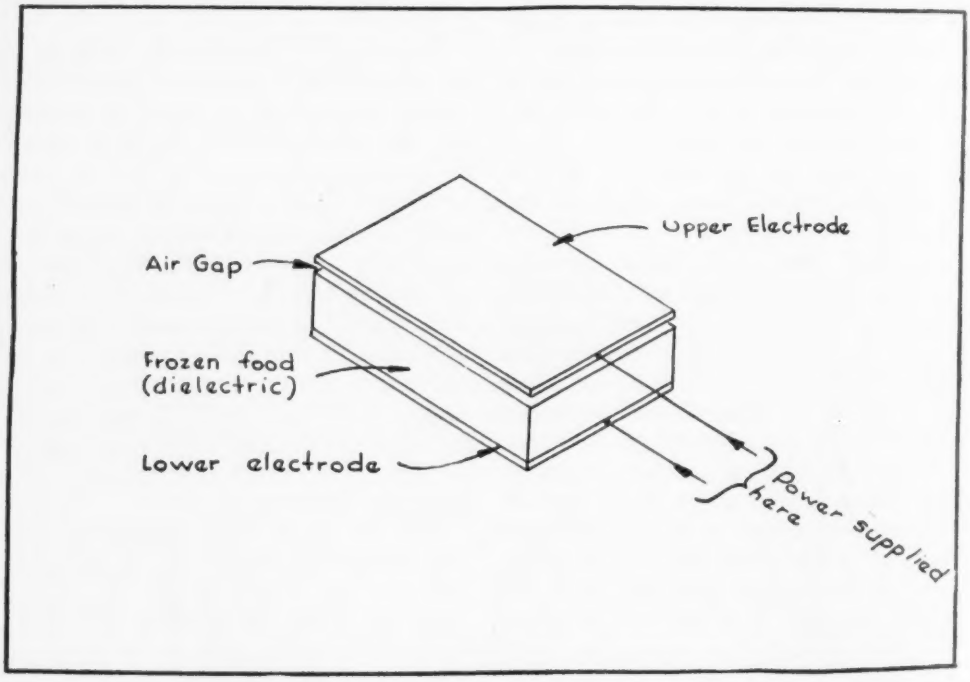

FIG. 9. FOR DIELECTRIC DEFROSTING EXPERIMENTS ON FOOD

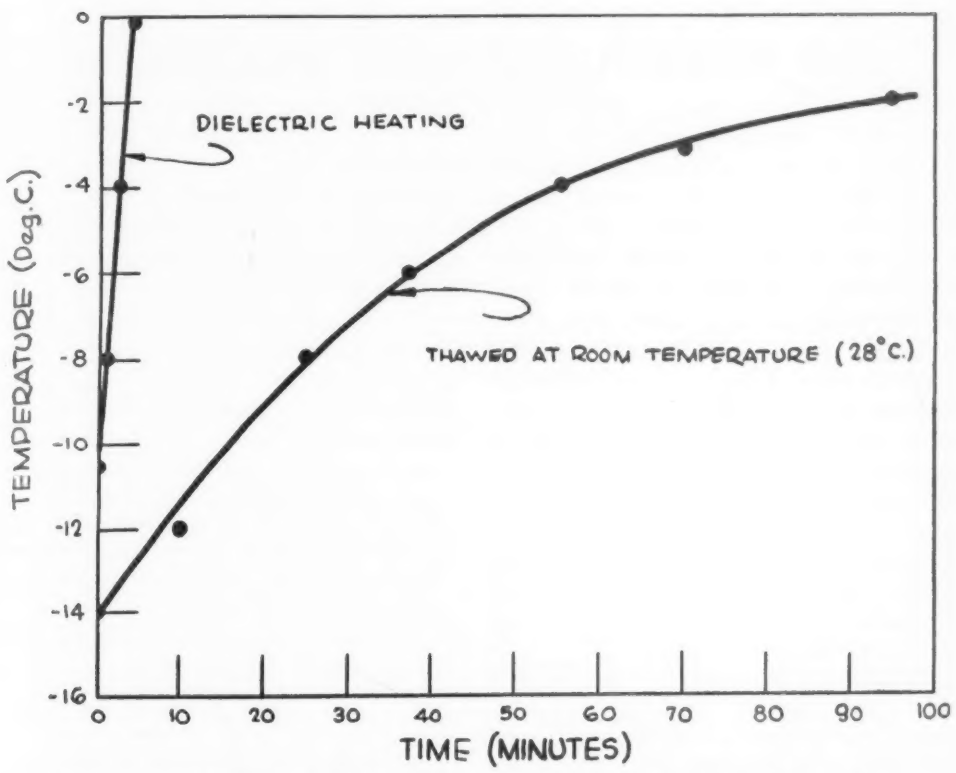

FIG. 10. THAWING FROZEN FOODS WITH TWO TYPES OF HEATING

the electrodes were connected to a high-frequency generator (Fig. 9).

Thermometers placed in holes drilled in the frozen material indicated the temperature at several points during the heating process. Typical observations are presented in Figure 10, where the temperature at the center of a one-pound package of frozen peas is plotted as a function of the heating time. For comparison, the temperature rise in a similar package is shown when the package was held in a room at 28° C. With dielectric heating the rate of temperature rise was practically uniform up to the melting temperature. On the other hand, the package held at room temperature warmed very slowly and at a continuously decreasing rate. These experiments show a gain in speed of thawing of about thirty times when dielectric heating is used. It is possible that much higher gains in speed may be obtained as more is learned about the process and it becomes possible to utilize more powerful generators. While these results are of an essentially preliminary nature because of the exploratory nature of the work, they do indicate the very great advantage of timesaving to be gained by the application of dielectric heating. Many problems remain to be solved before work of this character can be considered to be out of the laboratory stage. Much more information must be gathered in the laboratory concerning the basic dielectric properties of agricultural materials before engineers will have the information needed to design new equipment and new processes.

THE NEED FOR SCIENCE WRITING IN THE PRESS*

By RALPH COGHLAN
ST. LOUIS POST DISPATCH

NEWSPAPER science writers are actually translators. Their job is to translate scientific mumbo jumbo into plain English. It is not easy for several reasons. One is that a lot of scientists distrust the press. They have good cause for this. Some of the things the press has done to science are horrible to contemplate. The press has caused science acute embarrassment; we have sent scientists rocketing to the moon too many times; we have carelessly announced great discoveries that turned out to be fakes and fiascoes.

Watson Davis tells of the first science story he turned in to a city desk. It was one of the early reports that showed that goldenrod does not cause hay fever, but that it is caused instead by ragweed pollen. To Mr. Davis' amazement, the next morning the newspaper carried a very prominent page one story, "but," as he says sadly, "the copy desk in its infinite wisdom had corrected my error and the story told how goldenrod *does* cause hay fever."

We all remember the old Sunday supplement with its "knock-em-dead" stories about alleged scientific discoveries. We were told how we could have rosy cheeks that would last a lifetime. (This turned out to be merely a tattooing job.) We read headlines to prick the curiosity, such as "What Was the Huge Animal the Explorers Saw Disappear in an African Cave?" Or we were edified by the fact that dwarfs, giants, and freaks are now understood by science, with heavy emphasis, of course, on the dwarfs, giants, and freaks.

But the press is not altogether stupid; we are learning. In the excellent *New Yorker* "Profile" of William Laurence, of the *New York Times*, I find this passage:

> The daily press used to be both ignorant and suspicious of science, and generally avoided having to cope with it by ignoring it. Even the most significant scientific developments were slighted.
>
> The invention of the telegraph left the newspapers, which were later so heavily to depend on it, editorially bored, and when the telephone came along it evoked such comment as that of the *Dallas News*, which said smugly, "We must admit our incredulity is put to rather a strong test."
>
> Not a single reporter was present at the Wright brothers' first flight; the *Chicago Tribune*, showing even in 1903 a wondrous talent for steering a straight course of reaction, declined even to mention the preposterous goings on at Kitty Hawk.
>
> Newspapers touched on science only when they found a chance to poke fun at the absent-mindedness of its professors or to hint at strange new discoveries in the field of sex.
>
> Not until the last war broke out and the effectiveness of its weapons became evident did scientists get any respectful treatment, and even then relations between them and the press were not cordial, because nine-tenths of the time interviewers had no idea what their interviewees were talking about.
>
> Laurence is one of the men who have brought science and the newspapers together.
>
> Since 1926, when he began reporting science for the *World*, he has absorbed so much of it, and so rapidly, that he occasionally has to talk down to a scientist to put him at his ease.

Scientists have learned to respect men like Laurence, Watson Davis, Howard Blakeslee, Waldemar Kaempffert, and John J. O'Neill. These men actually represent a new type of journalism. In a sense, it is "pure journalism" in the

* From an address before the luncheon of the George Westinghouse Science Writing Awards, American Association for the Advancement of Science, March 27, 1946.

way that we use the term "pure research." These men do not have to write a story every day. They are not harassed by deadlines. It is their privilege to browse around the laboratories and in the scientific journals to winnow the important from the unimportant. They are given more liberty than the average reporter and are permitted to make judgments as to what is news in science instead of having men who do not know science tell them what scientific news is.

This method leads to a new trust between scientist and journalist, and the press has got to produce more journalism like this. It has got to produce more organizations like Science Service and more scientific staffs like those of the *New York Times* and *Herald Tribune;* it has got to produce more publishers like old E. W. Scripps, who said, "Damn it! If we have got to have a democracy, let's have an intelligent one." Mr. Scripps strongly believed that an intelligent democracy was one that knew something about science and the methods of science as a guide to everyday life.

I say the press has got to do these things because it *must*—Hiroshima and Nagasaki settled that. No matter how odious science is, the public must learn about it. The public must learn about it or else we will not be on this planet much longer. Perhaps it would be just as well. However, a lot of us would like to stick around yet for awhile. We want to see the day when scientists' little tricks with the atom can operate an automobile from coast to coast on a cupful of gasoline. (I believe I will take that back as I suppose it is still another piece of journalistic rot!)

WHILE I freely confess that the press has mutilated scientific theory, has misrepresented it, and has often unduly raised the hopes of many people by prematurely announcing cures of deadly diseases, there is another side to this picture. That is the fact that scientists themselves have too long lived in ivory towers. They have enjoyed to the full their intellectual snobbery. They have kept themselves aloof from the common herd. It used to be said that only twelve men in the world understood Einstein's theory of relativity. This must have given exquisite pleasure to those twelve men. It must have given even more pleasure to other scientists who rejoiced that their two-, four-, or eight-story minds were so superior to the minds of other men.

Scientists have not only lived in ivory towers; they have developed a lingo impossible for anybody but themselves to understand. It is actually a strange language. I should add that it is really a set of strange languages because very often one group of scientists cannot understand what another group of scientists is talking about. Like E. W. Scripps, Edward E. Slosson was preaching more than twenty years ago that science should be democratized and brought within the reach of the many.

Slosson in a *Century Magazine* article published in January 1922 said that if you suggest to a person he might find it interesting to study botany or chemistry he is likely to reply that he "had it as a boy," implying that, like mumps or measles, he could never catch it again. He criticized scientists for turning away eager lay minds with an attitude that seemed to say, "Run away, child. You couldn't understand what I am doing if I *did* explain it to you."

(I am, of course, not trying to disparage the exactness of statement which scientific terminology represents.)

To go back again to Mr. Slosson:

> The popularization of science does not mean falsification, but its translation from technical terms into ordinary language. Popular science need not be incorrect, but it has to be somewhat indefinite. It differs from the exact sciences in being inexact. The scientific mind is

set at too sharp a focus for ordinary use. The would-be popularizer is always confronted by the dilemma of comprehensible inaccuracy or incomprehensible accuracy, and the fun of his work lies mainly in the solution of that problem.

There is no excuse for a scientist to display his learning with big words when little ones would do just as well. What would you think, for example, of a scientist who would paraphrase Wordsworth in this fashion?

> A primrose by the river's brim
> *Primula flava* was to him and it was nothing more.

Or how would you like it if a scientist would express Lord Tennyson's famous line about a young man's fancy in this way: "In the spring the chief activating gland of the kinetic system, the thyroid, shows a distinct enlargement."

So, while I am perfectly willing as a member of the press to accept justifiable criticism from scientists for the way their facts have often been manhandled, the fault in the bad relations between science and the press rests with scientists, too.

I am glad the chasm between us is being bridged, even though we both still have a long way to go. We shall have to hurry to complete the bridge—the proper use and control of atomic energy makes that imperative—and I think we can confidently expect a more and more intelligent treatment of science by the press.

Newspapers have to deal often, among other things, with the intricacies of the legal profession. Many lawyers try to baffle us with their technical terms, just as scientists try to baffle us with their technical terms, but the lawyers have not been successful. If newspaper readers do not yet know the meaning of such monstrous legal phrases as "incorporeal hereditament," they perfectly well understand that when a fellow is thrown in jail it is often a writ of habeas corpus that gets him out. And the people have the right to know at least as much about enzymes and hormones as they do about habeas corpus.

The awful, as well as beneficial, discoveries of science have forced scientists into politics, and when scientists go into politics they will have to learn to talk the plain language of the people.

As Professor Harold C. Urey expresses it:

> I have dropped everything to try to carry the message of the bomb's power to the people because if we can't control this thing there won't be any science worthy of the name in the future. I know the bomb can destroy everything we hold valuable and I get a sense of fear that disturbs me in my work. I feel better if I try to do something about it.

A great many scientists feel the same way. A great many of them feel the most solemn obligation to prevent the atomic bomb from being controlled by our military men, and a great many of them feel that they must do something to defeat the May-Johnson bill, which would cripple scientific research.

In the March 1946 issue of *Harper's Magazine* there is a notable article on this subject by Joseph A. Brandt, who says: "The life of academic quietism is over. The man of learning, however well equipped he may be, must learn to become a man of action, a politician, a man of the people, speaking for people, leading people."

If the scientist does play this role, he must make full use of the press. The press, on its part, must develop more and more staff members who can translate the language of science into the language of the people. I hope a new relationship will come into being among science, politics, and the press—a relationship that will bring science closer to the people and that will enable man, by his knowledge of science, to control his own destiny.

CHARLES MASON AND JEREMIAH DIXON

By THOMAS D. COPE
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"STARGAZER" has a special meaning in Chester County, Pa., though it is now nearly 200 years since Charles Mason and Jeremiah Dixon came from England to set up their surveying instruments on the farm of John Harlan in Newlin Township. For the tradition persists among Harlan's descendants, who still own and cultivate the farm, and among the descendants of men who worked for Mason and Dixon that these two were unusual individuals who worked with remarkable instruments and spent much time mysteriously observing the stars. Except in this community, however, and to a few astronomers, geodesists, and perhaps a chance historian, the men Mason and Dixon are shadowy figures or "just surveyors."

Charles Mason laid the foundation of his career at Greenwich where he worked from 1756 to 1760 as assistant observer to the Reverend James Bradley, Astronomer Royal. Bradley was then near the end of his career (he died in 1762). As a young man he had discovered the aberration of light and the nutation of the axis of the Earth and had founded a new era of precise observations. He had enlarged the Greenwich Observatory and equipped it with new instruments. Mason acquired some of the spirit and the ideals of his preceptor and learned from him the use of instruments of precision and the art of observing. At Greenwich Mason made the acquaintance of the Reverend Nevil Maskelyne, a young astronomer who was assisting the Astronomer Royal in a study of atmospheric refraction. This association of Mason and Maskelyne continued as long as Mason lived.

And at Greenwich Mason first learned to know Mayer's *Tables of the Moon*. Early in 1755 Professor Tobias Mayer of Göttingen University had filed a claim with the Lords of the British Admiralty for one of the awards promised by act of Parliament of the fourteenth year of Queen Anne to discoverers of improvements in ways of finding the longitude at sea. In support of his claim Mayer had submitted in manuscript a new set of lunar tables with accompanying theory and other papers. In due course the Admiralty referred these claims and exhibits to the Astronomer Royal for investigation and report.

Bradley first reported on Mayer's *Tables* on February 10, 1756, and finally on April 14, 1760. With the assistance of Charles Mason, Bradley had compared positions of the Moon as predicted in the *Tables* with positions as observed at Greenwich. Eleven hundred comparisons led to the comment:

> So far as it will depend upon the lunar tables the true longitude of a ship at sea may in all cases be found within about half a degree and generally much nearer.
>
> It remained to be examined within what limits the errors arising from observations actually taken at sea could be contained.

This test was carried out for Bradley by Captain Campbell, of *H.M.S. Royal George*, on cruises near Ushant in 1758 and 1759. A sextant was made especially for the trials by John Bird, instrument maker for Greenwich Observatory. Bradley's final comment reads:

> However great the difficulties of finding the longitude by this method seem to be, they are not insuperable, or such as ought to deter those whom it most nearly concerns from attempting to remove them.

James Bradley was now nearing the end of his days. His hand was faltering,

Nevil Maskelyne and Charles Mason received the torch he had carried. They made the development of the method of lunar distances for finding the longitude at sea a major concern of the rest of their lives.

A transit of Venus across the face of the Sun was due to occur on June 5, 1761. It would afford a golden opportunity to determine the distance from Earth to Sun. To secure data observers would need to be stationed at strategic posts over the face of the Earth. The equipment needed would be simple—telescopes, timepieces, and instruments for measuring small angles.

Early in 1760 the Royal Society of London drew up plans to observe the transit at home and to send expeditions abroad, one to St. Helena where the end of the transit could be observed, the other to Sumatra where the whole phenomenon could be seen. Nevil Maskelyne was chosen to go to St. Helena, assisted by Robert Waddington; Charles Mason was selected to go to Sumatra with Jeremiah Dixon as assistant. Dixon was a surveyor and amateur astronomer from Cockfield in the county of Durham.

Both expeditions sailed from England as the year changed from 1760 to 1761. Mason and Dixon were carried by *H.M.S. Seahorse*. An engagement with a French man-of-war and accidents of wind and weather delayed their progress. They were obliged to disembark at the Cape of Good Hope and observe the end of the transit there. It occurred just after sunrise on June 5; weather was excellent.

Observations were reported by 176 observers from 117 stations. Perhaps the best commentary upon the work of Mason and Dixon on this occasion was written 130 years later. In 1891 the late Professor Simon Newcomb of the United States Naval Observatory published an exhaustive review of the transits of Venus of 1761 and 1769. To the observations made by Mason and Dixon at the Cape of Good Hope in 1761 he assigned weights that were among the very highest that he allotted.

In the early autumn of 1761 Mason and Dixon sailed from the Cape of Good Hope to St. Helena and joined Maskelyne and Waddington in a program of research that continued into 1762. Maskelyne had with him an astronomical clock made for the Royal Society by John Shelton. This clock is still in the possession of the Society and has been used on expeditions to many regions. Bradley had adjusted the clock at Greenwich and had found its rate of losing time when compared with the stars. Maskelyne had set it up on St. Helena with its pendulum at the same length and had found its rate there. Soon after his arrival at St. Helena, Dixon was sent with the clock back to the Cape of Good Hope for a similar determination.

The rates of a pendulum of constant length at various stations give relative values of gravity at these stations. They in turn permit inferences about the relative lengths of the polar and equatorial diameters of the Earth. Since Maskelyne was interested in the size and shape of the Earth, he continued to make determinations of gravity with John Shelton's clock. He took it to the Barbados during 1763 and 1764. In 1766 he sent it to Mason and Dixon in Pennsylvania, where they observed with it on Harlan's Farm.

Since at St. Helena the star Sirius in its diurnal motion passes near the zenith, its zenith distance as it crosses the meridian can be measured with precision. On account of its brightness Sirius was regarded as one of the nearest stars, probably with a large annual parallax. If this assumption were correct the zenith distance should change materially with the motion of the Earth in its orbit over a period of months. Maskelyne went to St. Helena prepared to measure the zenith distances of Sirius with a new zenith sector built for the Royal Society

by Jonathan Sisson. (A zenith sector is a graduated arc of a vertical circle provided with a telescope and plumb line.)

Maskelyne soon found that the manner of suspending the plumb line introduced serious errors into the readings. After his return to England he demonstrated to a committee of the Royal Society that the fault existed and that it had probably affected all zenith sectors previously built. The first sector free of this defect was built at once for Thomas and Richard Penn by John Bird and in the autumn of 1763 was brought to Philadelphia by Mason and Dixon. It was used by them in every determination of latitude they made in America.

His voyages to St. Helena and back to England and the voyage to the Barbados permitted Nevil Maskelyne to test the method of lunar distances and Mayer's *Lunar Tables* in finding the longitude of his ship. The outcomes were so encouraging as to lead Maskelyne to embody the method in a booklet for navigators that he published in 1763, *The British Mariner's Guide*.

James Bradley's successor as Astronomer Royal was Nathaniel Bliss, who lived only two years after his appointment. Maskelyne succeeded him early in 1765 and thus became the fifth Astronomer Royal at Greenwich.

In the meantime, on July 4, 1760, while the Royal Society was planning to observe the coming transit of Venus, the Proprietors of Maryland and Pennsylvania had entered into an agreement before the Court of Chancery to end their differences and forthwith to survey and mark their common boundaries. Both parties appointed commissioners from the provinces to carry out the articles of agreement. They in turn met at New Castle on the Delaware, agreed upon procedures, and engaged surveyors from Maryland and Pennsylvania.

The Middle Point of the peninsula between Delaware and Chesapeake bays had been determined, accepted, and marked in 1751. It is now the southwestern corner of Delaware. The eastern boundary of Maryland northward from the Middle Point to the Pennsylvania border was still to be surveyed. It was agreed upon as a straight line northward up the peninsula from the Middle Point until it made a tangent to the periphery of a circle of 12 miles radius drawn around New Castle. From the Tangent Point northward the boundary should consist, first, of that part of the circular arc that might lie westward of the meridian through the Tangent Point, and thence northward the meridian of the Tangent Point to an east-west line 15 miles south of the southernmost point of the city of Philadelphia. Except for slight errors made in surveying this describes the boundary as it stands today.

The provincial surveyors struggled to establish the Tangent Line from the spring of 1761 until the autumn of 1763. They ran a meridian northward from the Middle Point until the spire of the Court House in New Castle was in sight. Then they ran a radius out from the spire to intersect the meridian, measured distances and angles, calculated the position of the Tangent Point and the bearing of the Tangent Line. They set posts to mark the Tangent Point. Then they returned to the Middle Point and proceeded to lay off the Tangent Line. It fell half a mile to the east of the Tangent Point; a second trial ran 350 feet to the west.

The Proprietors were being kept informed of the progress of the survey. Both consulted Dr. John Bevis, and Thomas Penn sought advice from Dr. John Robertson, Master of the Royal Naval Academy at Portsmouth. Jonathan Sisson and John Bird were engaged to construct surveying equipment. As

months grew into years and as expenses mounted, the Proprietors became impatient.

Just who introduced Mason and Dixon to Thomas Penn is not clear. On June 18, 1763, however, Penn wrote to the Commissioners for Pennsylvania:

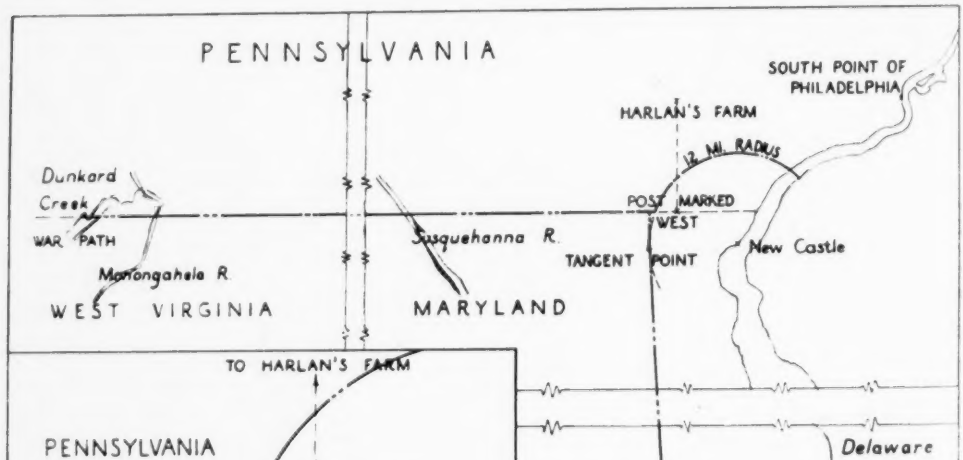
> We intended to persuade Lord Baltimore to join in sending some very able Surveyors that were skillful in making Celestial observations from hence, to this proposal we never got any consent of his till two Days since, . . . and Mr. Calvert joined with us in desiring the mathematicians, we proposed, to come to London, as soon as possible.

On August 10, 1763, he wrote to the provincial secretary, the Reverend Richard Peters:

> Mr. Mason and Mr. Dixon have taken their passages with Captain Falconar . . . and they have with them the fine Sector, two Transit Instruments, and two reflecting Telescopes, fit to look at the Posts in the Line for ten or twelve miles.

They carried also *Hints for Running the Lines* that had been prepared by John Bevis and Daniel Harris. The latter had succeeded John Robertson as mathematical master at Christ's Hospital.

Mason and Dixon arrived at Philadelphia on November 15, brought their instruments ashore, met the commissioners of both provinces, and took oaths to undertake the survey. With the aid of city authorities they selected the South Point of Philadelphia, erected a temporary observatory near it, set up John Bird's zenith sector, and measured the zenith distances of eight stars of Bradley's *Catalogue* as they passed the meridian. Apparent distances were corrected for refraction and were reduced for precession, aberration, and nutation to January 1, 1764. The latitude of the south point of Philadelphia as given by



IMPORTANT POINTS OF MASON AND DIXON'S SURVEYS

Photo by J. Carroll Hayes

THE HARLAN HOMESTEAD

IN JANUARY 1764 MASON AND DIXON MOVED TO THIS FARM WHICH BECAME THEIR HEADQUARTERS.

stars taken from Bradley's *Catalogue* was 39° 56′ 29.1″. Modern determinations make it only 2.5″ less.

In January 1764, the surveyors moved westward 31 miles to John Harlan's Farm, which became their headquarters. The observatory was erected, and the latitude was found. When the season opened, they moved southward from Harlan's along a meridian. Distances were measured as they proceeded, on level ground by chain, on slopes by levels. Again the latitude was determined, and a post marked "West" was set up in a field of Alexander Bryan's farm in New Castle County to mark the latitude 15 miles south of the South Point of Philadelphia. This post became the reference point for the parallel of latitude that separates Pennsylvania from Maryland.

For the next 4 years the survey proceeded. Vistas were opened through the forest, the Tangent Line was run, and the position of the Tangent Point was confirmed as marked. Northward, one mile and a half of circular arc and three miles and a half of meridian completed the eastern boundary of Maryland to the northeastern corner of the state in latitude 15 miles south of the South Point of Philadelphia.

The Parallel that separates Maryland and West Virginia from Pennsylvania was surveyed from the Delaware River to Dunkard Creek in the west. Agreement provided that it should span 5 degrees of longitude, but conditions in the Indian country halted its westward extension. The Five Nations provided an escort from the crest of the Alleghenies westward during the summer of 1767, but the escort refused to cross an Indian line west of the Monongahela River.

The Parallel was established step by step. Arcs of great circles were calculated to intersect the Parallel 10 minutes to the west. The arcs were run by transit. Then latitude was found by the zenith sector; offsets to the Parallel were calculated, and the Parallel was marked.

Historical Society of Delaware

THE TANGENT STONE

FROM THE DELAWARE SIDE. THE NEWER STONE WAS ERECTED IN 1849 NEXT TO THE ORIGINAL.

Vistas were opened along all lines. In the mountains to the west the Parallel was marked by cairns on the ridges; to the eastward the boundaries were marked by limestone monuments brought from England. Many of these markers are standing to this day.

On January 29, 1768, Mason and Dixon handed the map of the boundary to the commissioners.

MASON and Dixon spent five winters in America. The two winters following that of 1763–64 took them on excursions into neighboring colonies. The winters of 1766–67 and 1767–68 were spent at Harlan's Farm in scientific work for the Royal Society. Both men were acquainted with geodetic and geophysical measurements that had been made in Europe and on other continents. They themselves had used John Shelton's clock for determinations of gravity on St. Helena and at the Cape of Good Hope. They knew that in 1752 the Abbe de la Caille had measured an arc of meridian at the Cape and from it had calculated the length of a degree of latitude in that region of the Earth. In the same year the Jesuit astronomers Boscovich and Le Maire (the latter was from the same county in England as Jeremiah Dixon) had measured an arc of meridian across the Apennines from Rome to Rimini. For generations members of the French Academy had been measuring meridians in France, in Lapland, and in Peru. And in 1761 Cassini de Thury had begun to extend a parallel of latitude from Brest to Vienna. These projects had contributed data from which the size and shape of the Earth had been inferred, especially the flattening at the poles and the bulge at the equator.

No data had as yet been obtained from North America. In 1760 Father Roger Joseph Boscovich visited London. He was well received and was elected a fellow of the Royal Society. The record shows that he proposed to the Society that it measure a degree of latitude in America.

Before they had been long in America Mason and Dixon acquainted the Royal Society with the opportunities that were at hand along the Maryland-Pennsylvania boundary for measuring a degree of latitude and a degree of longitude. Their proposal was conveyed to the Council of the Society by Nevil Maskelyne. It received favorable attention on October 24, 1765. The project of measuring a degree of latitude was sponsored, funds were appropriated, instruments were supplied, the acquiescence of Lord Baltimore and the brothers Penn was sought, and the use of their instruments was bespoken.

Both the secretary of the Royal Society and the Astronomer Royal sent word of these decisions promptly. The latter drew up a letter of advice and instructions and forwarded it early in Novem-

Photo by C. H. Thomas

THE STARGAZERS' STONE

THIS MARKER, NOW PROTECTED BY A STONE WALL, WAS SET BY MASON AND DIXON ON MARCH 5, 1764.

ber 1765. Mason and Dixon were instructed to measure again the courses that linked the site of the observatory at Harlan's with the Middle Point. Both lengths and bearings were to be redetermined with all attainable precision. The latitude of the Middle Point was to be found and that of the site at Harlan's found again. To improve precision a 5-foot brass rod and 20-foot fir rods with brass ends, made by John Bird, were provided. Besides, there were sent a spirit level, silver wire for supporting plumb bobs, thermometers, and John Shelton's clock. Detailed instructions accompanied the instruments.

The first opportunity to work on the projects of the Royal Society came to Mason and Dixon in October 1766. They had just returned to the Maryland-Delaware peninsula from the Alleghenies, where they had spent the season extending the Parallel of Latitude westward. All work planned for the year had been completed except that of setting markers along the Tangent Line. On October 8 they arrived at the Middle Point and there spent 11 days in finding the latitude. The zenith distances of ten of Bradley's stars were measured repeatedly as they crossed the meridian. Corrections for refraction were made, and reductions for precession, aberration, and nutation.

In 1764 two courses had been run from the Middle Point toward the Tangent Point, one slightly to the west of it, the other to the east. The bearing of the former course was now remeasured at the Middle Point. The party then moved slowly northward along the boundary, checked bearings, measured offsets to the Tangent Line, and set permanent markers. From November 18 to 21 they

met with the Commissioners at Christiana Bridge, New Castle County, and were there instructed to extend the Parallel eastward to the Delaware River. This was completed by December 1.

The party then moved northward again and on December 5 established itself for the winter at Harlan's Farm. The zenith sector was set up just where it had stood 3 years earlier. Two astronomical clocks were mounted. One belonged to the Penns; the other was John Shelton's clock. The party remained at Harlan's until the middle of June 1767. The latitude was found with great precision. Eclipses of Jupiter's moons were observed to establish the longitude of the station. The pendulum of Shelton's clock was adjusted to the length prescribed by the Astronomer Royal, and by comparison with the stars its rate was found. Amplitude of swing and temperatures were recorded systematically. On May 24 there came a copy of the first issue of the *Nautical Almanac*, that for the year 1767, and a letter from the Astronomer Royal asking for a report of progress and directing that Shelton's clock be sent home at once, in order that it might be made ready for use in observing another transit of Venus expected to occur in June 1769.

The Parallel of Latitude was extended to its farthest west during the summer and autumn of 1767. The final report of the survey was handed to the Proprietors during January 1768. Mason and Dixon were then free to complete their projects for the Royal Society. They returned to Harlan's Farm on February 1 and at

Historical Society of Delaware

THE TRISTATE STONE

SET IN 1849 TO REPLACE A STONE ERECTED IN THE ORIGINAL MASON AND DIXON SURVEY AT THE TIP OF THE WEDGE (SEE MAP), WHICH WAS THEN REGARDED AS THE SOUTHERNMOST POINT OF PENNSYLVANIA.

once made ready to measure the courses that extended southward from that station to the Middle Point.

Levels had to be constructed. Joel Bailey, a local surveyor who had helped with the survey, was engaged to build sturdy frames of pine to carry the 20-foot brass-tipped fir rods. Each frame had a plumb line hanging in a tube at its middle. A frame was set up with its rod horizontal in the line being measured. Its position was marked to the hundredth of an inch on a stake set at the bottom of the plumb bob. The next frame was set in line with the rods end to end as shown by a plumb line. Temperatures were recorded. The rods were checked regularly against the Royal Society's 5-foot brass standard of length.

With all attention to detail the levels were applied first to the course 15 miles due south from the observatory at Harlan's to the Parallel. Then a shift of almost 3 miles due west placed them in the meridian of the Tangent Point. The levels were applied to this meridian until the Tangent Point was reached. Then the levels were carried westward and 90 feet southward to the arc of a great circle first run in 1764 and checked two years later. Thence a steady, patient march of almost 82 miles brought men and levels to the Middle Point on June 6.

Mason and Dixon returned to Harlan's Farm on June 16 and said farewell to it two weeks later. They settled accounts with the Commissioners during August and sailed from New York for England on September 11. "Thus ends my restless progress in America," wrote Mason at the end of their *Diary*.

From the data, Nevil Maskelyne found that the Middle Point lay south of the observatory at Harlan's 1° 8′ 45″ by celestial observations and 538,067 feet as measured horizontally over ground. Hence "363,763 English feet is the length of a degree of latitude in the provinces of Pennsylvania and Maryland." He analyzed the work and incorporated the result in a table of degrees of latitude that had been measured in Europe, South Africa, and South America between 1736 and 1768. (Immediately after its announcement Honorable Henry Cavendish pointed out that the Atlantic Ocean and the Alleghenies had probably deflected the plumb line of the zenith sector to an appreciable extent for which no correction could be made.)

Delaware Board of Agriculture
THE MIDDLE POINT
BETWEEN THE CHESAPEAKE BAY AND THE OCEAN.

Philadelphia in those days was the second city of the British Empire, and among its inhabitants was a coterie of men who were keenly appreciative of scientific progress. Charles Mason, Jeremiah Dixon, Nevil Maskelyne, and Joel Bailey were soon elected to the American Philosophical Society held at Philadelphia for Promoting Useful Knowledge.

For the guidance of observers of the transit of Venus which was to occur on June 3, 1769, Astronomer Royal Maskelyne published instructions as a supple-

Delaware Board of Agriculture

THE COURTHOUSE AT NEW CASTLE, DEL.

THIS WAS THE ORIGINAL CENTER OF THE ARC OF 12 MILES' RADIUS FORMING THE DEL.-PA. BOUNDARY.

ment to the *Nautical Almanac*. The Royal Society prepared to observe the transit at home and to send expeditions abroad. Western Europe was to see the transit begin before sunset; eastern North America would see its early stages during the afternoon; western North America, Alaska, and the Arctic regions would see the entire transit; and Australia, Asia, and eastern Europe would see its end after sunrise.

Astronomers of the American Philosophical Society established temporary observatories for viewing the transit on State House Square in Philadelphia, at Norriton, Pa., and at Lewes, Del. They made admirable records of the transit and sent them to the Royal Society. The Royal Society sent William Wales and Joseph Dymond to Prince of Wales Fort on Hudson Bay. They saw the entire transit from ingress to external contact at egress with highly favorable weather throughout. To observe the transit in the Pacific, the Society sent Lieutenant James Cook on the first of his famous voyages. His ship, the *Endeavour*, carried a distinguished company which included astronomer Charles Green and naturalist Joseph Banks. They observed the transit from Tahiti. "There not being a cloud in the sky from the rising to the setting of the Sun, the whole passage of the planet Venus over the Sun's disk was observed with great advantage."

Jeremiah Dixon and W. Bayley were sent to North Cape, Norway. Weather was unfavorable, and their observations were fragmentary. Charles Mason pro-

ceeded to Cavan, near Strabane, in county Donegal, Ireland, established an observatory, and made records for the Royal Society from April 3 to November 28, 1769. His report on time, latitude, and longitude is a masterly one. He made complete records of the beginning of the transit.

Years later the astronomer Encke studied and restudied the data secured in 1761 and 1769. In 1835 he announced the conclusion that the Earth is 95,370,000 miles from the Sun, a distance accepted as correct for the next 30 years.

Sir Isaac Newton had predicted that a "hemispherical mountain 3 miles high and 6 miles broad will not by its attraction draw the plumb line 2 minutes out of the perpendicular." In 1738 members of the French Academy had tried to measure the attraction of Chimborazo in South America, with inconclusive results. Bouguer, who reported the attempt, proposed that a similar experiment be tried in France or England. In 1772 Maskelyne proposed to the Royal Society that "the Attraction of some Hill in this Kingdom be measured by Astronomical Observations." The proposal was approved, and in 1773 Charles Mason was sent north to find a hill "of sufficient height tolerably well detached from other hills, and considerably larger from East to West than from North to South." He chose Schehallien in Perthshire, Scotland.

Maskelyne established an observatory on the south face of Schehallien in the early summer of 1774. He set up Jonathan Sisson's zenith sector and measured the zenith distances of stars in Mason's table as they passed the meridian. Then his instrument was carried over the mountain to its north face where similar observations were made of the same stars. The differences made it appear that the instrument had been moved 54.6 seconds of arc northward. The difference in latitude was independently found by two triangulation surveys from

U. S. Coast and Geodetic Survey

GRANITE MONUMENT NO. 222

ERECTED IN 1865 BY SINCLAIR TO MARK THE NORTHWEST CORNER OF MARYLAND. PHOTO TAKEN IN 1900.

two carefully measured base lines on the plain below the mountain. Both agreed in placing the second station 42.94 seconds of arc north of the first.

The difference—54.6 less 42.94, or 11.66 seconds—was attributed to the deflection of the plumb line of the zenith sector by the mountain. During the triangulation the dimensions of the mountain were measured, its rocks were surveyed, and its mean density was estimated. The deflection of the plumb line permitted an estimate to be made of the mean density of the Earth. In this project instruments were used that have been met before: Sisson's zenith sector; John Shelton's clock; and the Royal Society's 5-foot brass standard.

THE last quarter of Charles Mason's life was spent on projects that grew out of his earlier work at Greenwich Observatory as assistant observer to Astronomer Royal Bradley. From studies of Bradley's records Mason prepared tables for the *Nautical Almanac* and he was able to improve Mayer's *Tables of the Moon* by comparing them with the Greenwich records.

The *Nautical Almanac* was established by Nevil Maskelyne in 1767, immediately after his appointment as Astronomer Royal, and it has appeared annually ever since. In the first issue the latitude and longitude of Cape Town are given as found by Mason and Dixon in 1761. The comment follows that "it is probable that the Situation of few Places is better determined."

To the *Almanac* for 1773 Mason contributed a catalogue of stars. The preface, written by Maskelyne, states:

> To this Ephemeris are annexed . . . a Catalogue of 387 fixed Stars . . . adapted to the beginning of the year 1760 . . . calculated from the late Dr. Bradley's Observations by Mr. Charles Mason, formerly his Assistant. . . . After the Catalogue follow some Memoranda . . . communicated by the same Mr. Mason.

The issue for 1774 first introduces Mason's improvements of Mayer's *Lunar Tables*. The preface written by Maskelyne on July 2, 1772, states:

> To this Ephemeris are annexed 1220 Longitudes and Latitudes of the Moon deduced from the late Dr. Bradley's Observations. . . . The greater part of these calculations were made during Dr. Bradley's Lifetime by himself and his Assistant Mr. Charles Mason; and what was left unfinished has been completed by Mr. Mason since at the Instance and at the Expence of the Board of Longitude.
>
> A Series of Observations this for Number and Exactness far excelling anything of the same kind which the World ever saw before. . . .
>
> Accordingly the Board of Longitude have thought proper to employ Mr. Mason farther in making the necessary calculations for improving Mayer's printed Tables under my Direction. . . .

The introductory pages of the *Almanac* for 1776 include a digest of legislation of the fourteenth year of King George III which had become effective on June 24, 1774. Rewards were set for timepieces, lunar tables, and other aids to navigation and finding the longitude.

References to new work by Mason appear in the prefaces to the *Nautical Almanac* for 1777 and for 1788. Finally, in the preface to the *Almanac* for 1798, which he signed on December 2, 1791, Maskelyne summarizes Mason's work on the Moon's position:

> The Moon's Place in the Heavens was inserted as calculated directly from Mayer's *Tables* in the *Nautical Almanac* from 1767 to 1776 inclusive, or the first ten years,
>
> But from the *Nautical Almanac* of 1777 to that of 1788, both inclusive, or the next twelve years, the Moon's Place was inserted as calculated from new *Tables*, improved from Mayer's *Tables*, composed by Mr. Charles Mason. . . .
>
> But from the *Nautical Almanac* of 1789 to 1796, both inclusive, the Moon's Place was inserted as calculated from new *Tables*, still further corrected by Mr. Mason, entitled by him the *Tables of 1780*, as having been completed about that time. . . .

Maskelyne then proposes small corrections to Mason's *Tables*.

February 9, 1765, is a cardinal date in the story of Mayer's *Tables*, for on that

day Astronomer Royal Maskelyne laid before the Commissioners of Longitude reports of his own success in using the *Tables* for finding the longitude on his recent voyages to St. Helena and to the Barbados and also reports from masters and mates of ships of the East India Company. Upon hearing the evidence the Commissioners adopted resolutions to print Mayer's *Lunar Tables*, to seek authority from Parliament to establish a *Nautical Almanac*, and to pay to the widow of Mayer (for he had died in 1762) a sum not to exceed £5,000. The widow Mayer was granted £3,000. The *Tables* were published in 1770, and Maskelyne signed the preface to them on February 23 of that year.

Mason's tables of 1780 were published by the Commissioners of Longitude in 1787 under the title *Mayer's Lunar Tables improved by Mr. Charles Mason.* Mason never saw them in print. At the close of the eighteenth century Mason's were the most esteemed tables of the Moon. They were used in preparing *The Nautical Almanac* and in computing *La Connaissance des Temps.*

James Bradley had not published his Greenwich observations. In law they proved to be his personal property, and after his death they were claimed successfully by his only child, a daughter, and her husband, the Reverend Samuel Peach. They in turn gave the records to Oxford University where Bradley had studied and had held the Savilian professorship of Astronomy. The first of Bradley's records to be published was the catalogue of stars that Mason prepared for the *Nautical Almanac* of 1773. The Clarendon Press of Oxford University undertook the publication of all the records. The first volume appeared in 1798 under the editorship of Professor Thomas Hornsby. It includes Mason's star catalogue. Mason and Hornsby carried on an extensive correspondence about the Greenwich records that undoubtedly aided in preparing them for the press. The second volume, edited by Dr. Abram Robertson, appeared in 1805. Finally in 1832 there was published *The Miscellaneous Works and Correspondence of Reverend James Bradley* under the editorship of Professor S. P. Rigaud.

Jeremiah Dixon was made a fellow of the Royal Society on November 18, 1773. Little appears to be known of his remaining years. A bachelor, he died at his birthplace in Cockfield, Durham County, in 1779, where his father owned and operated a coal mine. Descendants of his brother have attained distinction as engineers and as amateur astronomers.

After long years the Commissioners granted Charles Mason £750 for his services to navigation in improving Mayer's *Tables;* his annual pay had been meager. On September 27, 1786, he wrote to Benjamin Franklin that he had just arrived in Philadelphia with a wife, seven sons, and a daughter, all in helpless condition; that he was ill and confined to his bed. It is not known what had brought him to America again; it is possible that it was the opening of the public land survey in eastern Ohio. With his letter to Franklin he enclosed a sketch of an astronomical project that would involve little expense.

Early in November 1786 Philadelphia newspapers announced that Mason had died there on October 25, and that while ill he had given his manuscripts and scientific papers to the Reverend John Ewing, provost of the University of Pennsylvania. Mason had known Ewing as a mathematician and astronomer of his own age who had served as a commissioner for Pennsylvania during the survey of the boundaries. No trace of the manuscripts and papers or of the astronomical project has been found.

Nevil Maskelyne long outlived his two contemporaries. He died with the harness on his back at Greenwich Observatory in 1811, at the age of seventy-nine.

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SCIENCE ON THE MARCH

FROM DUNGEON TO MANSION

In the February SM under the title "From Dungeon to Tower" I described and illustrated our present inadequate quarters in the Smithsonian Institution Building and I appealed again to our readers to contribute to our building fund. According to Dr. H. A. Meyerhoff, who records and acknowledges the receipt of building fund checks, the influx of contributions was accelerated by the publication of that doleful tale. As a few checks were sent directly to me by readers of the article, I know that it was not without effect. Therefore, on behalf of the Association, I thank those who responded to this and to previous appeals in the SM.

By the time the present article appears all readers of the *A.A.A.S. Bulletin* and *Science* will know that their contributions were not in vain; that they enabled the Association to take advantage of an extraordinary opportunity to acquire at a reasonable price the most desirable property for our purposes in the city of Washington. If we had had the right of eminent domain and unlimited funds, I think we would have chosen the same spot. If there are any readers of the SM who have not seen the *A.A.A.S. Bulletin* for May, I urge them to get it and read Dr. Moulton's lucid and complete story of our future home and its acquisition. I can add nothing to his account except the photographs and sketches here published.

FIG. 1. THE NEW CAMPUS—SCOTT CIRCLE

AS SEEN FROM A WEST WINDOW OF THE HEADQUARTERS BUILDING. HERE FOUR STREETS INTERSECT, ALL BUT ONE BEING ARTERIAL HIGHWAYS. OTHER SCIENTIFIC INSTITUTIONS ARE LOCATED NEARBY.

From the top of the terrace in front of the west side of the mansion shown below the photographer directed his camera toward Scott Circle. The resulting view from the house is seen in Figure 1. The statue in the distance is that of Daniel Webster. The equestrian statue of General Winfield Scott occupies the center of the Circle. In the right foreground beneath the large ginkgo tree stands a memorial to S. C. F. Hahnemann, the founder of homeopathy.

FIG. 2. THE NEW HEADQUARTERS OF THE A.A.A.S.
AT 1515 MASSACHUSETTS AVENUE, WASHINGTON 5, D.C. THIS MANSION WILL HOUSE THE ADMINISTRATIVE AND EDITORIAL OFFICES OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FIG. 3. FOUR HOUSES ON THE A.A.A.S. PROPERTY

AT THE BASE OF THE TRIANGLE SHOWN IN FIGURE 4. THE RENTALS FROM THESE HOUSES WILL PRODUCE REVENUE FOR THE ASSOCIATION UNTIL THEY ARE REPLACED BY A MODERN OFFICE BUILDING.

Figure 2 shows the 26-room, red-brick mansion that we shall occupy. The west side of the house, surmounted by two chimneys, faces Scott Circle. The entrance, between the glassed porch and the two-story bay, faces Massachusetts Avenue and bears the number 1515.

The headquarters building is one of five on the Association's property. The four remaining houses, totaling 47 rooms, are pictured in Figure 3. They constitute a solid red-brick row on Fifteenth Street. The entrance to the house capped by a dome is on Massachusetts Avenue. The occupants of these rooming houses will become tenants of the Association.

Figure 4, a plat of the property, shows the lots on which the five houses stand. Figure 5 shows that the Association's property is a small city block bounded

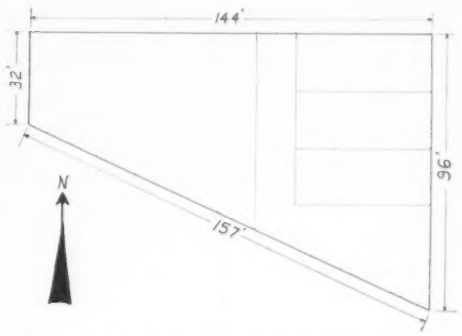


FIG. 4. PLAT OF THE PROPERTY

THE HEADQUARTERS BUILDING STANDS ON THE LOT AT THE APEX OF THIS BLUNT TRIANGLE.

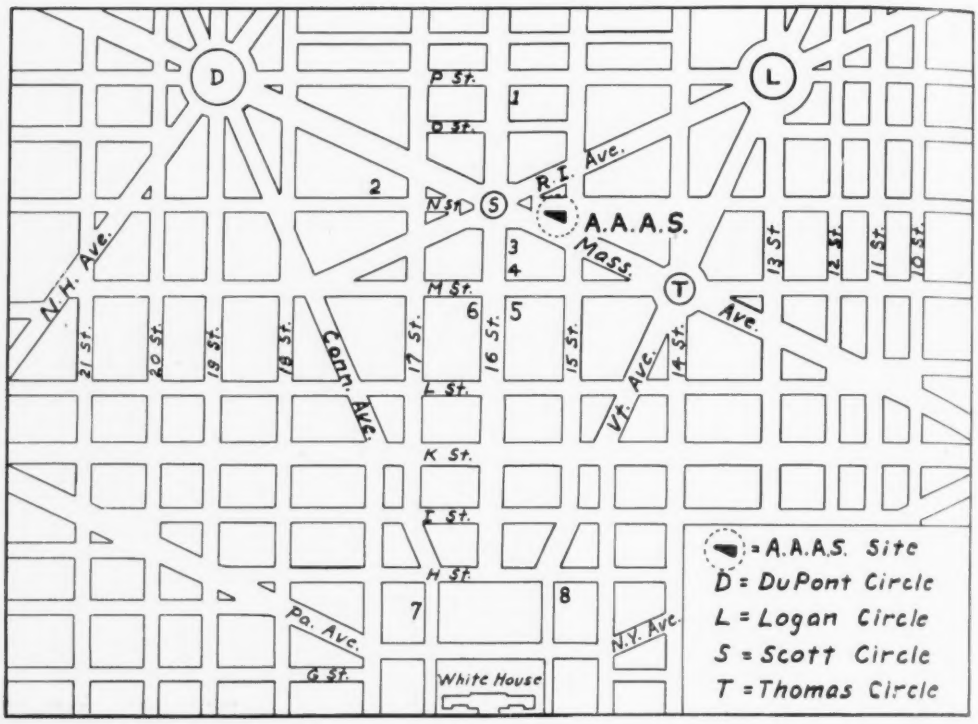


FIG. 5. THE CENTRAL LOCATION OF THE A.A.A.S. SITE

EASILY ACCESSIBLE BY ALL FORMS OF TRANSPORTATION, THE A.A.A.S. SITE IS NEAR OTHER SCIENTIFIC INSTITUTIONS: (1) CARNEGIE INSTITUTION OF WASHINGTON; (2) SCIENCE SERVICE; (3) AMERICAN COUNCIL OF LEARNED SOCIETIES; (4) NATIONAL EDUCATION ASSOCIATION; (5) AMERICAN CHEMICAL SOCIETY; (6) NATIONAL GEOGRAPHIC SOCIETY; (7) BROOKINGS INSTITUTION; (8) COSMOS CLUB.

on the north by N Street, on the east by Fifteenth Street, on the south by Massachusetts Avenue, and on the west by Scott Circle. Strictly speaking, this area of 9,275 sq. ft. is a trapezoid, but I think of it as a blunt triangle. On a somewhat larger triangle on the other side of N Street stands a modern mansion of the embassy type.

The purchase of the triangle on Scott Circle not only raises our hopes for the distant future but relieves our minds about the immediate future. It was imperative that a solid shelter be secured for the staff of *Science* before winter. Now we not only have a building in which we can all work together but we have a home that will suffice until it becomes possible and advantageous to build a permanent structure for the Association and for those affiliated societies that wish to be housed with the Association.

Let it not be supposed that our building-fund campaign is concluded. To purchase the property the money so far provided had to be supplemented by funds from general operations of the Association. Furthermore, we shall have to pay for repairs and maintenance of the old buildings. We have merely taken the first important step that will lead eventually, we hope, to the construction of a modern building for the Association on the splendid site that we have acquired.

Science, as represented by the Association, is on the march!

F. L. CAMPBELL

GOLD SHADOWING IN ELECTRON MICROSCOPY

THE electron microscope has been the subject of discussion in this magazine at least three times, but since this is a developing invention there is more to be reported now. The purpose of this paper is twofold: (1) to bring a few nontechnical references to the attention of readers; and (2) to report an important new development known as gold shadowing, by means of which a third dimension in the specimen under observation can be made evident and even measured.

In THE SCIENTIFIC MONTHLY for August 1939 (pp. 189–192) F. R. Moulton reported an address by V. K. Zworykin, who had returned from Europe with news of the latest developments in the microscope up to that time. Dr. Moulton, with his background of knowledge of the difficult astronomical problem of separating close double stars, was able to set forth clearly the basic reasons why this new method of taking photographs with a beam of electrons will give a far more highly magnified image of minute structures than can possibly be given with a microscope using light, even ultraviolet light.

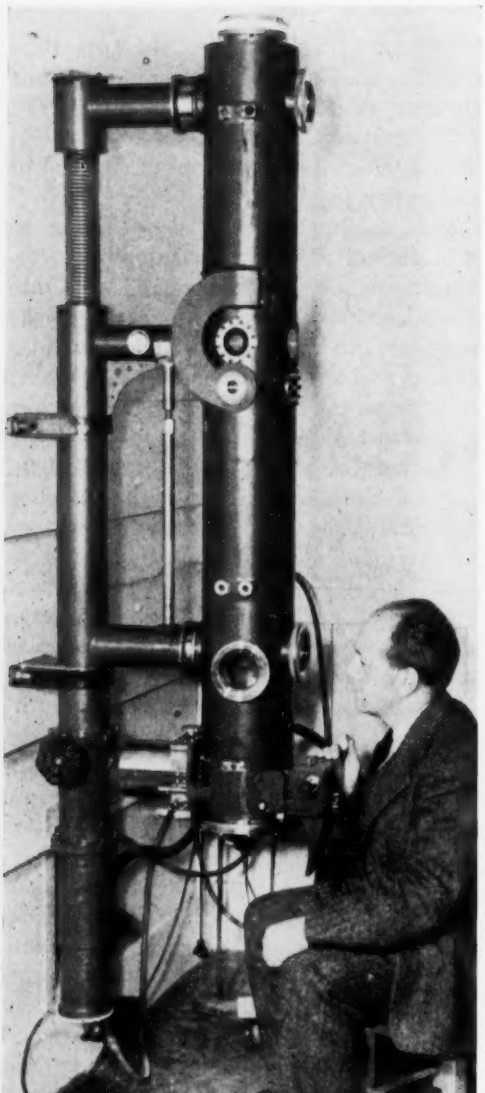
Another early paper published in THE SCIENTIFIC MONTHLY (pp. 337–341, April 1941) was prepared by Theodore A. Smith, of the RCA Laboratories. It describes the form of electron microscope already being manufactured by RCA for use in research institutions. A comparison is made between this instrument and the ordinary light microscope showing that their parts are analogous but that where one uses lenses for focusing, the other employs electric coils to guide the negatively charged electrons to their focus. Also, the general principles of magnification by means of electrons are covered in nontechnical language.

Three years later V. K. Zworykin, Director of Research at RCA, and James Hillier contributed to THE SCIENTIFIC MONTHLY of September 1944 (pp. 165–179) a good, detailed account of the electron microscope and its work. The gold shadowing process had not then been perfected and was not mentioned in this paper.

Gold shadowing, or shadow-casting, as it is also called, is a preparatory processing of the specimen before it is put into the microscope to be photographed. Its purpose is to bring out stronger contrasts in the picture and to show the heights of irregularities on the surface of the specimen.

As carried out by Ladislaus Marton, one of the developers of the process, working at the electron optics laboratory of Stanford University, shadowing is very similar to aluminizing an astronomical mirror. (Fig. 1.) A bit of gold is evaporated in a vacuum and is allowed to deposit on the object to be magnified by the microscope. Atoms of the vaporized metal naturally fly off with considerable speed from the source of heat, and some of them fall upon the microscopic specimen. The result is a thin film, less than .000,001 mm. thick on the specimen.

The specimen for the microscope and a tungsten filament with a little gold on it are both put under a bell jar. The surface of the specimen to be coated with gold is set several centimeters from the hot filament. Its surface is not turned directly toward the filament, but is tilted about 70° away. Air is then pumped from the bell jar, and the filament is electrically heated to evaporate the gold. Every upward projection on the specimen will intercept the falling gold particles as a hill or a house cuts off sunlight and casts shadows on the landscape. The result is a "shadow" on the specimen where no gold falls. The angle of 70° corresponds to the angle at which the sun's rays fall upon the earth in the late afternoon when shadows are long.



Courtesy of L. Marton

FIG. 1. ELECTRON MICROSCOPE

THE ADJACENT PHOTOGRAPH WAS TAKEN WITH THIS MICROSCOPE AT STANFORD UNIVERSITY.

The specimen thus gilded is put into the electron microscope and photographed in the usual way. Electrons can pass through the shadowed places where there is no gold film, and when these electrons reach the sensitized plate they darken it (in the negative) as light would do. But the gold film, thin as it is, prevents electrons from passing through it and therefore from ever reaching the plate. These unexposed parts of the photographic plate remain clear. Thus the original negative (or a double printing, to provide the picture in negative form on paper) presents a view such as is seen in Figure 2.

A gold-shadowed electron micrograph, as compared with an unshadowed micrograph, shows the same improved clarity of relief that may be seen in a telescopic view of the new moon. Contrasted with the almost featureless full moon, the strong lights and shadows of the quarter moon show mountains and craters, hills and valleys, with great distinctness.

It should be said, however, that not all microscopic subjects require shadowing; the great density and correspondingly low transmitting power for electrons that is natural in some specimens is sufficient to show clear outlines, although without showing thickness or relief. It is the delicate specimens such as virus particles, nearly transparent to electrons, that require shadowing in order to make them stand out plainly.

As the astronomer can measure the height of a lunar mountain peak or crater rim by measuring the length of its shadow and taking into account the slant of the sun's rays, so the biologist with his gold-shadowed picture can measure the thickness of a virus particle or a bacterium in the same way.

Metals other than gold have been tested for shadowing. Chromium was used but its minute structure is such that a chromium film must be about ten times as thick as a gold film in order to intercept the electrons. Gold is fine-grained, and its heavy atoms check the progress of electrons.

The first published report of shadow-casting appeared in a paper by Ladislaus Marton and L. I. Schiff, in the *Journal of Applied Physics* (**12**, pp. 759–765,

1941). Antimony was being evaporated onto a collodion film, and the observance of shadows behind dust particles was incidental to the main work in hand, which was a study of various kinds of films.

Three years later R. C. Williams and R. W. G. Wyckoff, of the University of Michigan, in a paper published in the *Journal of Applied Physics* (**15**, pp. 712–716, 1944) showed that height determinations can be made from such shadows. These two workers have since reported improvements in metal shadow-casting. Their most recent article (*Journal of Applied Physics*, **17**, pp. 23–33, January 1946) shows beautifully shadowed specimens magnified up to 60,000 times. The text of the article may be found a little technical for the general reader unacquainted with previous explanations.

Only illustrations can convey to the mind any true conception of the meaning of magnifications around 50,000. The following bizarre comparison will perhaps be as effective as any other in giving the true significance of the high magnifications possible with the electron microscope. If a woman's hair a foot in length could be made to appear 50,000 times its real dimensions, it would be 10 miles long and each individual strand of hair would be 10 feet in thickness!

The micrograph used on the front cover of the January 1946 *Journal of Applied Physics*, illustrating the article by Williams and Wyckoff, shows those small aggregations that approach true molecular dimensions and so are named "macromolecules." In the same article is shown another illustration of macromolecules of an organic compound, accentuated by gold shadowing and then enlarged to more than 50,000 diameters. The particles in this illustration, standing like scattered trees, cast their long shadows on the level ground surface.

Photo by Rawlins and Marton

FIG. 2. TOBACCO MOSAIC VIRUS

A GOLD-SHADOWED VIEW OF VIRUS RODS MAGNIFIED 40,000 TIMES. NOTE ALSO THE BACTERIUM WITH ITS LONG AND SINUOUS FLAGELLUM.

An informative, nontechnical, and highly novel discussion of electron microscopy is to be found in the Sigma Xi magazine *American Scientist* (pp. 247–254, July 1943). Adopting Lewis Carroll's style, Ladislaus Marton conducts Alice through "Electronland" and interprets her wondering comments by explanatory notes of his own that throw light on the eerie situations in which she finds herself among the weird but real creatures brought out of oblivion by the electron microscope.

WILLIAM T. SKILLING

SAN DIEGO, CAL.

COMMENTS AND CRITICISMS

Another Error?

The February issue of *Reader's Digest* contained an article by Owen Johnson which it credited to THE SCIENTIFIC MONTHLY of January 1946. In this article Mr. Johnson, in referring to the Civil War battle between the *Monitor* and *Merrimack*, is quoted as stating that "there was no question of where the victory lay."

I have not had access to the original article, but, if Mr. Johnson is quoted correctly [he is], I believe that his statement is not correct. In fact, Southerners to this day insist that the *Merrimack* was the better ship and they base their claim on the fact that on two occasions subsequent to the original battle she challenged the *Monitor* to fight, but the *Monitor* would not do so. For a period of two months after the battle there was acute apprehension, at times bordering on panic, lest the *Merrimack* steam past the *Monitor* at Hampton Roads, put out to sea, and proceed to bombard Northern cities. For defense against this danger, Federal officials relied not on the *Monitor*, but on ocean liners sent to Hampton Roads with instructions to ram the *Merrimack* should she venture to get out into the high seas. As for the *Monitor*, Washington officials who knew her warned that she was not capable of coping with the *Merrimack* and she was ordered not to attack the Southern ship unless the latter got into a position where the ocean liners could ram her.—ROBERT STANLEY MCCORDOCK.

Three in One

The paper "The Strange Trinity Called Man" by A. Boyajian, which you printed in the April issue of THE SCIENTIFIC MONTHLY, I think was most excellent. You should be commended for printing it. Whether the personality of a human being is actually divided up as he indicates, I am not in a position to offer an opinion, but whether that is a fact or not, I think his paper is worthy of careful consideration, as it sets the personality problem forth in rather a novel light.

Perhaps I should say that I have been interested in psychology and psychiatry for some years, you might say as a hobby, but of course strictly as a layman. I have thought for some time of the human being as not a unit of personality, but as a family of personalities in one body; although I had not thought this out enough to put any limit to the family, or to give any definite characteristics to the different members, as Mr. Boyajian has done.

I certainly hope that some of our eminent psychologists and psychiatrists see fit to comment on this paper, and that you will print the same in a future issue of THE SCIENTIFIC MONTHLY.

I think this should convey to you my appreciation of this paper, and I will not intrude further on your time. I will only add that there are many other papers in THE SCIENTIFIC MONTHLY that I find very interesting, but which do not quite move me to the point of writing you about them.—HAROLD L. DEYOE.

St. Paul and Psychiatry

It grieves me to see hypocrisy in the writings of my fellow technical men. This is a word most frequently thrown at religionists but I think it applies as well to A. Boyajian, author of "The Strange Trinity Called Man" in the April 1946 SCIENTIFIC MONTHLY.

First, because this article gives out unscientific opinions under the guise of scientific fact. It seems trite to mention that science is an absolute body of knowledge gathered by trained observers using the method of observation, experiment, and experience. Is it unreasonable to ask how in the name of science one is to accept Mr. Boyajian's analysis of St. Paul's experience on the road to Damascus? "Vas you dere, Charlie?" Is Mr. Boyajian's analysis more to be trusted than St. Paul's own description of his experience?

Second, because a biased opinion is here given under the guise of being unbiased. So many fine things have been said by men of science about "unbiased facts" that we have grown to think of the two as being synonymous. One does not have to be a mind reader to recognize Mr. Boyajian's opinion of St. Paul as being biased. We have come to associate bias and bigotry with ecclesiasticism. Is it possible that some of us prefer "scientific" bigotry to religious bigotry? Science forbid!

Mr. Boyajian's selection of Scripture references to illustrate his points reminded me of the classical Biblical injunction to commit suicide immediately. "Judas . . . departed and went and hanged himself" (Matt. 27: 5). ". . . Go and do thou likewise" (Luke 10: 37). ". . . That thou doest, do quickly" (John 13: 27). Judging from the manner in which Scripture is used in this and other articles in THE SCIENTIFIC MONTHLY it seems to me not absurd to suggest that these writers could with profit spend some time in a Sunday School.—PAUL W. HOLLOWAY.

Thanks, Mr. Wormser!

I was startled to see in the April number of THE SCIENTIFIC MONTHLY in the most interesting article by Mr. A. Boyajian the letter from Cotton Mather to John Higginson. This letter has been repeatedly shown to be a pure forgery. In T. J. Holmes' *Cotton Mather Bibiliography*, pages (1299) to 1300, you will find a full account of this hoax in which are reprinted the remarks of Mr. Samuel A. Green at the 1908 meeting of the Massachusetts Historical Society.

This spurious letter perennially reappears, generally in learned publications, in spite of repeated published exposés.—RICHARD S. WORMSER.

Some Like It Hot . . .

May I congratulate you and your associates on the manner in which you have broadened the range of interest of THE SCIENTIFIC MONTHLY.

In the last [August] issue I was particularly impressed by the article on religious truth. In the current issue the articles by Black and Weltfish are especially impressive.

Naturally, THE SCIENTIFIC MONTHLY must have articles which are predominantly scientific and experimental. However, nothing in the field of science is more important today, it seems to me, than the discussion of values as contrasted with facts, morals as contrasted with materials, and idealism as contrasted with pragmatism.

If the atomic bomb has not made this obvious, then there is no hope for the human race. The atomic bomb represents a collection of facts; the decisions as to how the bomb is to be made use of must be based on an agreement in respect to fundamental values. Therefore, it seems to me that such discussions as those referred to in the MONTHLY, and other articles on religion and morals written from a scientific viewpoint, are highly appropriate for the MONTHLY.—HENRY C. LINK.

Some Like It Cold . . .

I subscribed to THE SCIENTIFIC MONTHLY with the hope and pleasant expectation of reading a magazine completely devoted to *science*. It is with deep regret that I see that I made a mistake. Unless you want deliberately to deceive your readers you must change the title of the magazine to something like: Religion and Science, or Bible Stories. . . .

If you continue to disgrace the pages of your magazine with metaphysical rubbish I will discontinue my subscription.

Yours for a real Scientific Monthly,

J. M. MARTINEZ

A Soft Answer . . .

Dear Professor Transeau:

Thank you for sending me a copy of your letter to Dr. Campbell and for giving me an opportunity to reply. First, as to some matters of fact:

(*1*) In my article [Basic English for Science, March SM] there was no designation of any particular book to which my student's letter referred. I do not know what book she had in mind. It might have been any botany text available to OSU students. If you feel that a book in which you are interested is in question, you are assuming an onus which was not intended. You say, quite correctly, that your text and teaching methods are not properly described in my student's letter. Why, then, call them into question? The quotation, which you designate as "alleged," is not taken from your book.

(*2*) The implication in your use of "purloined" is unjust. The letter was used with the student's permission. I believe that you will agree that in withholding the student's name, I was only acting with ordinary discretion.

(*3*) I chose a specimen of Lyell's prose because it is *not* extremely technical. I could easily have found specimens more in need of simplification; to choose these would have seemed like begging the question.

(*4*) Basic English versions *have* been made of many of the English classics, including one of the three you mention. These versions are intended to serve as introductions for Basic readers whose mother tongue is not English.

There remain the two questions as to whether the language of some science texts might be simplified and whether Basic can help in this. These questions are matters of opinion, and I do not need to add here to what I have already stated. I do feel, however, that the increasing demand for simplification made by our students is being amply supported by many scientists and technicians. One MONTHLY subscriber wrote to me saying, in part: "Your article in the March SCIENTIFIC MONTHLY ought to be required reading for a good many of the the people who write scientific books and articles." Another: "I think that the point which you make should be given serious consideration by all writers in science, and I am pleased that the editors of SM have endorsed it." I shall be glad to open to you, Professor Transeau, my complete correspondence file on this article.

Thanking you again and assuring you of my personal esteem, I remain,

Sincerely yours,

TOM BURNS HABER

THE BROWNSTONE TOWER

The flag on the Brownstone Tower now flies at half-mast for Chief Justice Stone. The sky is cold and gray, and the Smithsonian is almost deserted on this last Saturday in April. But Spring will not remain long in mourning. She will appear again more resplendent than ever until every tree is fully clothed in green. She came first in March in a yellow burst of Forsythia. Then she displayed her cherry blossoms and apple blossoms, and now her principal attraction is pink and white dogwood.

With blossom time come visitors to Washington. By automobile and bus, by train and plane, they converge upon the nation's capital. High school boys and girls are getting the thrill that comes but once as they gaze upon Washington for the first time. They climb the stairs of the Monument and see all the sights in the daytime. They are too excited to sleep and finally go home exhausted but very happy.

One visitor made me aware of the prevalence of a tree that bears pyramids of violet-purple flowers. It is called the royal paulownia and is related to catalpa. From one of the bridges across Rock Creek Park it can be seen as a purple canopy along the stream. This spectacular tree was introduced from China—many years ago, no doubt, for a hollow veteran stands near the Smithsonian. Old Hi Ho believes that a bear hibernates in that tree. He never passes it in winter without mischievously tossing something into a hole in the trunk to stir up the alleged animal.

By the time this issue reaches the reader another exotic tree, *Albizia julibrissin*, will be in bloom. This low, crooked tree deserves to be called feathery, for the pinnae are small and numerous. It is named the silktree, perhaps because its pink flowers are as fine as silk. Here at the northern limit of its range the silktree ornaments many a street and yard, blooming through June and July. Near the Washington Cathedral one may sit on a bench under the shade of a silktree to wait for a bus.

Speaking of busses, I should like to say a good word for the Capital Transit Company and its employees. Having sold my car during the war, I am now dependent on public transportation to move me and my briefcase between the Brownstone Tower and my home in Rockville, Md. I take a street car to the District Line and a bus from there to Rockville. One night I worked in the Tower later than usual in order to complete the contents of an envelope for the printer. It was doubtful that I could mail the envelope and catch a streetcar in time to make my bus. I walked as fast as I could across the Mall to Ninth and Pennsylvania Avenue where my streetcar was in sight. Lacking time to put my envelope in a mailbox, I boarded the car and consulted Operator 3032. He solved my problem; at Fourteenth and Pennsylvania Avenue he stopped the car long enough for me to get out, drop my envelope in a box, and return to the car—a service that must have been unprecedented in the heart of a big city. Yes, I caught my bus.

There are no subways in Washington as yet, but numerous rush-hour busses and streetcars enable the passenger to travel expeditiously. A free map of the transit system is easy to obtain, and if one buys a weekly pass, he can ride easily and inexpensively wherever business or fancy dictates. I like Washington.

F. L. CAMPBELL

BOOK REVIEWS

A STUDY OF THE PINE RIDGE SIOUX

Warriors without Weapons. Gordon Macgregor, with the collaboration of Royal B. Hassrick and William E. Henry. 228 pp. Illus. $3.75. The University of Chicago Press. 1946.

IT IS heartening to witness a gain in the scientific approach to Indian administration. Although confronted with a social problem of contacts between two races and the impact of "superior" Western culture on the life-way of preliterates, the Indian Service has come, somewhat belatedly, to call upon students of man to institute studies toward an intelligent policy of Indian education. It was scarcely ten years ago that former Commissioner Collier opened the Service to anthropologists. At first they were viewed with suspicion and assigned to a wide variety of tasks ranging from community worker to reporting how proposed constitutions for tribal governments would fit the social organization and present condition of tribal communities; it was not expected that their findings would lead to formulation of policy. Of the first class of "applied" anthropologists who had their introduction to Government and their eyes opened in the Indian Service a majority went on to tasks outside the Service, but one has become an Assistant Commissioner, and Gordon Macgregor stayed on in the Education Division, carrying over the tradition of ethnological field studies to its application in research for Indian education. He is currently superintendent of the Tongue River Indian Agency, Mont.

The Indian Education Research Project, of which this volume is the second of five integrative studies, brought together members of the Committee on Human Development, of the University of Chicago, and the United States Office of Indian Affairs. To the cooperating moieties who, in keeping with the times, had a coordinator, there was appended an Advisory Committee comprised of nineteen big-name anthropologists, psychologists, and analysts, and Indian specialists who participated in varying degrees. At the operational level, the Sioux Project Staff under Macgregor enrolled a second anthropologist, Hassrick, from the University of Pennsylvania, and enlisted as field workers mainly members of the educational and medical staffs of the Pine Ridge Agency. This unit was one of five such teams studying the Sioux, Hopi, Navaho, Papago, and Zuni tribes, and they had as their over-all objective " . . . to investigate, analyze, and compare the development of personality . . . in the context of the total environmental setting—sociocultural, geographical, and historical—for implications in regard to Indian Service administration." The entire project was intended as the first step in a long-range plan of research, which would attempt ultimately to evaluate systematically the entire Indian administrative program, with special reference to a new policy that recognizes Indians as individuals. If, as we hope, the findings of such studies are taken seriously, we may see fulfilled the application of scientific methods toward increasing the effectiveness of Indian administration.

Beginning in 1941, the research program sought a common method for coopting the resources of a large group in the University of Chicago who represented related disciplines in the social and medical science fields. Each specialty contributed such techniques as were suited to developing a common methodology, training field workers, doing field work, and analyzing and inter-

preting data. What kind of results followed on applying the emergent "method of sociopsychological analysis" to one of the five tribes?

The Sioux Project did not attain its goal of investigating the personalities of one thousand children, selected by age groups from six to eighteen years old and representing two or more communities in each tribe, in the context of the total environmental setting. School children were accessible for observation and testing, and they underwent a battery of psychological tests (both projective and performance); to get life histories parents were interviewed, as were teachers and other members of the community; medical examinations filled out the picture. This field work was combined with analysis at the University. Present Sioux culture was studied on the reservation, and for history and the physical environment an abundant literature existed.

Kyle, Wanblee, and Pine Ridge town were the three districts selected for study as showing varying adaptations to white culture. The first, an Indian school district comprising several native communities, received greatest attention. The second, a farmers' market town that lost its white population during the depression, resembles the first in racial composition. Pine Ridge, the Agency town, shelters white civil servants, mixed bloods, and Indian wageworkers. With an eye to racial composition of the tribe, Sioux children, aged six to eighteen, were selected at random from the day schools and from one boarding school of these districts for psychological testing. Case histories were assembled, however, for only 166, of whom 40 percent were full bloods.

The method of testing and interviewing is adequately explained and can be reviewed elsewhere. What interests us is how such information was interpreted against the background of the Pine Ridge community and Sioux culture. Of particular significance is the influence of changing Sioux culture on present social disorganization, with attendant repercussions on personality orientation.

While not negating the biological basis of personality, Macgregor's research follows the "... thesis that personality and individual development ..." follow a number of complex processes—organic, psychological, social—which "... operate to influence and shape personality and behavior." The study makes one further assumption—that the whole personality reacts in any given situation of overt behavior in response to some "need," objective, or purpose of the individual. Meaning of behavior depends on the entire personality, its demands and experiences.

The Cultural Background of Personality (Part I) describes Dakota life then and now—how they lived, the road to civilization, and the economic basis of modern reservation society, contrasting values and attitudes of prereservation culture with those retained or acquired since 1876. The cultural anthropologist finds greatest relevance in the forepart of the study. Here is classic Dakota culture separated along generational and blood lines, so that the process of acculturation finds striking illustration in the grandparental generation of warriors (mostly full bloods), parents who attended boarding school, essayed cattle ranching, first succeeded, then failed, and the present crop of day school children. If one might generalize from a visit and the literature, Macgregor's picture of the Teton-Dakota as a living culture would be confirmed.

> Not only economic activity is lacking in Indian homes; there is little interaction in the community. The tempo is slow and quiet, and life is marked by an idleness that reflects apathy as well as lack of full-time occupation.

Moreover, he notes a great variety of Indian habits and ways of living and in

personalities which segregate on blood and generational lines. That these divisions rest on *sociological* rather than *biological* group factors must be remembered and will re-emphasize the point that being an Indian is primarily a state of mind. Membership in the full-blood group, which comprises more than half the tribe, is a sociological value.

From Mekeel's study we know the stages of Dakota acculturation, in these aspects: (*1*) suppression of Indian custom and authority, (*2*) education of children to white life, (*3*) Agency pressure on adults to adopt white ways of earning a livelihood. What Macgregor's study brings out, however, is the story of the Indian adaptation to cattle ranching and the demonstration, implicit also as family background in case histories of individuals, that

> the loss of their cattle herds was the greatest disaster that had befallen the Pine Ridge Indians since the vanishing of the buffalo. . . . The extermination of the buffalo has often been pointed out as the basic reason for the present disorganization of the Plains Indians. [It] . . . was the deathblow to Plains Indian culture, but the present predicament of the Pine Ridge Dakota is not a direct result of this episode. . . . [The loss of] . . . the cattle . . . economy in the sales of 1916–17 and the subsequent land sales, appears as the most significant single catastrophe in the history of the Pine Ridge people.

From an administrative viewpoint the preponderant dependency of the Pine Ridge Dakota on government (state and federal, 52 percent, 1942) poses a tough problem. Preferring cash income from wagework, the Dakota now derive less than one-third of all income from land resources. How arrest this trend?

The treatment of family life glosses over kinship patterns, transcending the usual interests of social anthropologists to consider breakdown factors. Symptomatic of cultural breakdown is the pattern of children voluntarily living away from parents.

How whites transmit their culture, most readily as employer-farmers, highlights relations between neighboring communities in which the Indians merge with lower rather than middle-class South Dakota whites.

Enough detail crept in from Hassrick's study of Dakota religion to make one wish for more. Prohibition took away the religious and social security that the Sun Dance provided. Upon the acceptance of Christianity, to which were transferred the values of power, equality, generosity, asceticism, and virginity, the native cults took refuge in secrecy; particularly, rites associated with curing go on to a greater extent than missionaries or officials are willing to believe. The Dakota of one generation gave up one form of ritual at life crises, and another form was taken up by the next generation. No direct substitution occurred; it was acculturation by succession. We hope that Hassrick's "Teton Dakota Religion" (ms.) will detail peyote practices and the Yuwipi cult, the latter having escaped previous ethnologists.

The value system of old Dakota culture, resting on four principles—honor, bravery, generosity, and wisdom (moral integrity)—came into conflict with white values between the generation of grandfathers and fathers. Cooperation gives way to individual enterprise, attachment to land relaxes, and hospitality preventing accumulation breaks down off the reservation. Social controls, too, weaken as the Pine Ridge people feel two cultures but do not live completely in either, with resultant insecurity for the group and for the individual.

For a while in Part II (Growing up on the Reservation) the cultural anthropologist walks *pari passu* with the student of individual development. Both observe children, but cultural features begin to give way to factors in child growth. Nevertheless, the study overlooks postures in childbirth. And the hammock blanket pinned through two loops of rope

hung from the ceiling may not be recent since it occurs among the modern Iroquois (unless both learned it from a common source traveling with circuses).

Nowhere are our two cultures in greater contrast than in early training. Full-blood Dakota do not use baby talk but teach their children Siouan. And:

> White people will sit outside an Indian home in bewilderment and utter frustration watching children tear a headlight off a car or drag good harness over the ground in play, while the parents sit by undisturbed. To the whites it seems preposterous that people who are so poor should allow children to damage useful objects that have been earned with great difficulty. This is part of the lack of concern over property that underlies the Dakota virtue of generosity; it is also a way of teaching children not to set a high value on property.

Also of interest to students of child development are the onset of fraternal associations and avoidance of girls. Social distance widens between the sexes from six through adolescence. Aggressive behavior of boys (hitting girls in school) is deeply ingrained in Dakota culture, is manifested in violence, and girls greatly fear the boys.

The study also brings into bold relief the institutional character of boarding school society, how it increases social and cultural distance and time from reservation life. The reader can understand how a career in the Indian Service looms as a goal to the studious child, since the to us rather drab life of an agency civil servant really contrasts colorfully with lackluster reservation life. Without detracting from the distinguished service record of the Sioux in the recent war, we can now see that it was not entirely the warrior tradition of the Plains that inspired their youth to seek honor. They gained "satisfaction from the sense of equality with other young people and from being wanted in the outside world—a satisfaction that these Pine Ridge youths have never felt before."

The case histories of Dakota children help to conceptualize the Personality of the Dakota child (Part IV). They seem real enough, and I suppose they are typical. Reading the cases throws light on the development of personality in our own culture. We can be grateful that we fortunately inhabit a sector of society in which the culture imposes fewer strains on the individual, that gives greater security, less anxiety, and some hope. Evidently Dr. Wm. Henry saw these children clearly and interpreted the tests with fidelity.

Indian Service personnel cannot afford not to read this study. Administrators cannot continue to ignore what is happening to the culture and personality of the people whom they serve. Unless there be rewarding goals in life on the reservation, such as might be attained by the restoration of Dakota cattle economy, no amount of public health education per se or enriching the land through scientific agriculture will provide the will to live in these people.

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THE SCIENTIFIC MONTHLY

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Founding and Organization

In 1848, on September 20, the Association was formally organized and held its first meeting; in 1874 it was incorporated under the laws of the Commonwealth of Massachusetts and given the right to receive, purchase, hold and convey property. Its governing body is a Council, now having 255 members.

The Association is national in scope, with membership open to the whole world on equal terms, and its interests include the broad fields of the natural and the social sciences. Its varied activities are carried on under 16 sections with which 190 affiliated and associated societies, having a combined membership of nearly a million, cooperate in organizing programs for its meetings.

Members and Meetings

All persons engaged in scientific work, all who find pleasure in following scientific discoveries, all who believe that through the natural and social sciences a better society may be achieved are eligible for membership in the Association. From its founding, the most distinguished of American scientists, including every American Nobel Laureate in science and every president of the National Academy of Sciences, have been members. The names of many university presidents, of eminent scholars in widely different fields, and of men notable for public service, including a United States Senator, a Justice of the Supreme Court, and a former president of the United States, are now on its roll of more than 27,000 members.

The Association's meetings are field days of science attended by thousands of participants at which hundreds of scientists vie with one another for the pleasure and the honor of presenting results of researches of the greatest benefit to their fellow men. An enlightened daily press reports their proceedings throughout the country.

Opportunity and Responsibility

A world torn by conflicts and fearful of the future is looking more and more toward scientists for leadership. The opportunity for unparalleled service is theirs and the fact that they have available the only essentially new methods, if not purposes, imposes an equal responsibility. For these reasons it will be the Association's steadfast purpose to promote closer relations among the natural and the social scientists, and between all scientists and other persons with similar aspirations, to the end that they together may discover means of attaining an orderliness in human relations comparable to that which they find in the natural world about them.

MEET THE AUTHORS

ADOLPH KNOPF, Ph.D., is Sterling Professor of Geology in Yale University. He was born in San Francisco in 1882 and received his undergraduate and graduate training at the University of California. He began his professional career in 1905 as a Geologic Aid on a U. S. Geological Survey party engaged in exploratory work in the region between Dawson on the Yukon and Fairbanks, Alaska. As the Chief of Party believed in fully utilizing the long Arctic daylight, all hands were up at 4:30 every morning. After five more field seasons in Alaska Dr. Knopf was transferred to the Metalliferous Section of the Survey for work in the States. Numerous reports resulted on the geology and ore deposits of many districts in Montana, Nevada, and California. In 1920 Dr. Knopf was called to Yale, where he became Professor of Geology in 1923. One of his major interests in recent years has been the measurement of geologic time by radioactive methods. He was President of the Geological Society of America in 1944.

OWEN JOHNSON, B.A., is a well-known novelist and short story writer. He was born in New York City in 1878, the son of an editor. He began writing for publication as a child. At the Lawrenceville School and at Yale he edited literary magazines. Later he fictionized his school and college experience in *The Eternal Boy* and *Stover at Yale*. The latter, which was a best-seller, is no doubt remembered by our older readers. *The Varmint* and *The Tennessee Shad* are also familiar titles. At Stockbridge, Mass., where he now lives, he has won prizes for his fruit, vegetables, and flowers and he has taken an interest in polities to the extent of becoming a candidate, in 1936 and 1938, for the Democratic Congressional nomination. Although Owen Johnson is a familiar name to us, we wonder whether he ever heard of the SM before *The Reader's Digest* planted "John Ericsson" in the Tower.

NEW BOOKS

SM readers are already familiar with Samuel Brody for he has been a frequent contributor to its pages. We have now received from the Reinhold Publishing Corporation, a copy of what appears to us to be his *magnum opus, Bioenergetics and Growth* ($8.50). The book represents an integration of the results of the researches sponsored by the Herman Frasch Foundation for Research in Agricultural Chemistry at the Missouri Agricultural Experiment Station. The major purpose of these investigations was to make a comparative study of the energetic efficiencies of agricultural processes, such as those concerned with the production of meat, milk, eggs, and muscular work, along with the factors influencing these efficiencies. Many of the technical aspects of this research have been published in a series of bulletins that have become famous as "Brody's Bulletins." The book is valuable for several reasons, not the least of which is the completeness of its coverage of the field. In addition, it presents for the first time a complete reference work that can be utilized by scientists whose own fields impinge on this particular field to develop correlated studies. Two criticisms might be made. The subject index would have increased value for other researchers if references to specific animal groups had been collated and tabulated. The second criticism relates to the complexity of the charts which in many cases are reproduced from the author's bulletins.

U S D A, Manager of American Agriculture by Ferdie Deering (University of Oklahoma Press, $2.50) is an attempt at critical evaluation of the success of the United States Department of Agriculture in carrying out its assigned tasks on a wide front. The author states as his thesis that the job of the Agriculture Department is to see that American agriculture—more specifically, the man behind the plow—keeps the country's 140 million well-fed, and to insure the agricultural population against the more formidable hazards of its free enterprise system. Mr. Deering is the editor of one of the country's leading agricultural magazines, *The Farmer-Stockman*, and he asks such pointed questions as, Has the department solved some of the problems that beset rural America? What have been the scientific achievements of the department with all of the untold millions placed at its disposal? What are the real costs of its services? His answers can be surmised by the titles of his last two chapters, "The New USDA" and "Tomorrow's Agriculture."

NEW BOOKS, Continued

We fully expected to be swamped with books on atomic energy and we have not been disappointed. Most of them show the effects of hasty efforts to reach the market before the sales resistance of buyers increases. One book which does not fall in this category is *Uranium and Atomic Power* (Chemical Publishing Company, Inc., $4.00) which is co-authored by Jack DeMent and H. C. Dake. It is a book intended for layman and chemist alike. The book gives extended treatment to the occurrence and properties of uranium minerals, an important factor which was omitted in the first hurried books. Further evidence that the book is the result of well-considered planning is the inclusion of several chapters on the subject of uranometry, comprising methods used in the detection and determination of uranium.

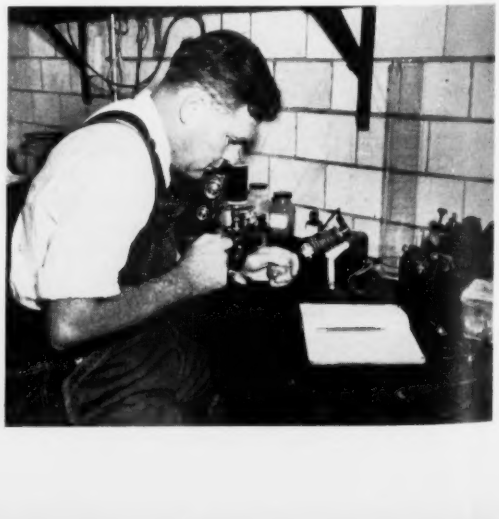
This column seldom refers to fiction, but we are breaking our rule for the sake of mentioning a detective book on the subject of atomic power. The author is J. B. Priestly, the well-known British novelist, and back in 1938 he wrote a "thriller" under the title of *Domesday Men*. Harper & Bros., the publishers, probably thought that their man had gone to a joss house for a turn at the pipe—but now, of course, they know better. The interesting feature of the book is the extensive knowledge that Priestly possessed of atomic energy and his skill in weaving a plot around it. There is one further recommendation and we make it in all seriousness. One feels a strong undertone that Priestly thought that atomic power, if it remained under the control of scientists who were dominated by a dictator complex, could make life a whole series of Hiroshimas.

Our good friend and frequent book reviewer, M. F. Ashley Montagu, has recently published *An Introduction to Physical Anthropology* (Charles C. Thomas, $4.00). In his introduction, Dr. Montagu admits that he has endeavored to compress within a few hundred pages a subject that could easily use as much space as the entire *Encyclopedia Britannica*. The lay reader and budding anthropologist should find it a valuable introduction to the subject. Anthropologists with an interest in anthropometric measurement will want to cast an appraising eye over the principal appendix which is titled "A Practical Synopsis of Methods and Measurement in Physical Anthropology." At the end of each chapter there is a list of further references for those who would pursue the subject further.

MEET THE AUTHORS, Continued

WILLIAM GORDON WHALEY, Ph.D., is temporarily Senior Geneticist in the Bureau of Plant Industry's wartime rubber project, to which he came from the staff of Columbia University where he had been teaching genetics and morphogenesis. He desires and expects to return to teaching. Dr. Whaley was born in New York City in 1914, took his B.S. at Massachusetts State College and his Ph.D. at Columbia. During the war he was responsible for the genetical and physiological research and general research coordination of nine field stations and several cooperating research groups. This work required him to travel extensively in Central and South America. We saw enough of Dr. Whaley in the Tower to wish that we knew him better.

PAUL D. HARWOOD, Ph.D., Director of Research for Dr. Hess and Clark, Inc., Ashland, Ohio, was born in 1906 on a farm in Niagara County, N. Y. His undergraduate work was done at Cornell and his graduate work in systematic zoology at Rice Institute. His later work at Vanderbilt Medical School and with the USDA was with anthelmintics. In protest against the advertising man's white-coated scientist we could not refrain from showing Dr. Harwood (below) at work in overalls. He is a big man of wide biological interests. At present he uses his spare time (would that we had some!) enlarging a small collection of local dragonflies.



MEET THE AUTHORS, Continued

HENRY P. HANSEN, Ph.D., is Assistant Professor of Botany and Head of the General Science Department of Oregon State College. He was born in 1907 at La Crosse, Wis., and went to the University of Wisconsin for his undergraduate and part of his graduate work, which he finished at the University of Washington. Prior to going to Oregon State he taught at the Universities of Washington and Wyoming. Dr. Hansen has been working on peat bogs since 1929 when he became interested in the tamarack bogs in the Driftless Area of Wisconsin. Since 1935 he has been working on pollen analysis of the sedimentary columns of the Pacific Northwest. Like his collaborator, Dr. L. S. Cressman (see p. 51), he has been a Guggenheim fellow. During the period of his fellowship (1943–44) he completed his work on the postglacial vegetation of the Pacific Northwest. His chief professional interests are in paleobotany, ecology, and taxonomy, and his principal hobby is gardening.

IRA S. ALLISON, Ph.D., Professor of Geology at Oregon State College, is probably a modest man. Although he has given us little information to indicate that he counts in geology, he must be highly regarded, for he was chosen to go to Europe to teach in the Army's Educational Program. We do not know which of the three universities claimed his services. Dr. Allison was born on a farm in Illinois in 1895 and received his A.B. degree from Hanover College in Indiana in 1917. After two years' service in the Army in World War I he began his graduate work at the University of Chicago and finished it at the University of Minnesota where he received his Ph.D. in 1924. He taught geology at the University of Minnesota before he went to Oregon State College in 1928. Dr. Allison is co-author of a textbook on geology and author of numerous articles on the geology of the Pacific Northwest.

NEW BOOKS, Continued

In ancient times, volcanoes were regarded as the dwelling places of gods that had to be propitiated at all costs. Thomas Jaggar, who refers to himself as a "Volcanologist" has set down the results of 25 years of probing into this highly specialized field. The result, *Volcanoes Declare War* (Paradise of the Pacific, Honolulu, $3.75) is a book to be read by anyone from ten to sixty-five. It has a group of 32 plates that are most unusual. Dr. Jaggar has dedicated his book to Mrs. Jaggar, and we want to quote this dedication in full, because it is the tribute that should be paid to that patient partner of every scientist, his wife.

To helpmeet and campmate

ISABEL JAGGAR

Whose horse crushed her against a tree . . .
Whose gloves fell into a red hot crack and burned up. . . .
Who slept in a lava tunnel beside the immortal remains of a desiccated billy goat . . .

And loved it all.

We can think of many such women who have been as the mate of the cardinal—shy, retiring, and never seeking the limelight. It is good to see public recognition accorded them. While it is late to suggest that you give a copy of this as a Christmas gift, it is good enough for any gift time.

A few lines above we mentioned a book that put the Department of Agriculture under the microscope. The month's new books brought us two titles that set into bold relief the kinds of problems that make such a department necessary. Cornell University Press has just published *The World's Hunger* ($1.50) by Frank A. Pearson and Floyd A. Harper and Macmillan has issued *New Crops for the New World* ($3.50). Pearson and Harper set forth their argument in the preface as the fact that "there is no scarcity of land with favorable topography, or adequate sunlight and carbon dioxide, or favorable temperature, or reliable rainfall, or fertile soil, or adequate rainfall." Considering, however, the factor that there is a serious shortage of land with the proper combinations of these seven items, they argue that something should be done about it. To their minds one of the basic "somethings" is to educate the man who must eat to live and this book is their attempt at constructive effort in that direction. *New Crops for the New World* is a symposium edited by Charles Morrow Wilson. In it are contributions by sixteen authorities from several

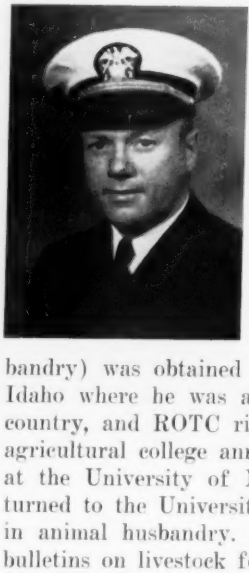
NEW BOOKS, Continued

American countries. The book might well be considered an answer to that of Pearson and Harper, for it points out the many places yet available for both intensive and extensive cultivation and tells about many yet unexploited kinds of food that could give variety and strength to our present diets.

We would not go so far as to assert that there has been connivance between the SM authors and the publishers, but it is a fact that it is a long time since we have had books from three of them within the same month. The third SM scribe to get printer's ink on his hands this month is our faithful adviser, Dr. Edward J. Stieglitz, of Washington. Dr. Stieglitz is the famous son of a famous father and many of SM's older readers will remember well the tenure of Dr. Julius Stieglitz as chairman of the chemistry department at the University of Chicago. The Commonwealth Fund has sent us Dr. Stieglitz' monograph *A Future for Preventive Medicine* ($1.00). Geriatrics and gerontology are part and parcel of every physician's practice, for we start to grow old the moment we start to live. For years Dr. Stieglitz has given study to the problems of growing old in a young manner. In this new book he strikes out boldly for more research in public health and medicine with particular emphasis on the health problems of middle and old age.

Science and Scientists in the Netherlands Indies is a special supplement of *Natuurwetenschappelijk Tijdschrift Voor Nederlandsch Indië* issued by the Board for the Netherlands Indies (10 Rockefeller Plaza, New York, $4.00). Its editors are Pieter Honig and Frans Verdoorn, both eminent and internationally famous Dutch scientists. In it, by means of original articles, reprints of hitherto unavailable accounts, biographical sketches, and a list of scientific institutions, societies, and workers, the editors have endeavored to present a picture of the development and status of a number of branches of the natural sciences, pure and applied, in the Netherlands Indies. The entire book is done with the extreme carefulness that has characterized the work of Dr. Verdoorn's well-known *Chronica Botanica*. Full use is made of cuts, maps, diagrams, and artistic drawings made in the islands. One could wish, without criticizing, that such a well-prepared book might have been accorded the extra financing that would have made possible the use of a larger type size.

MEET THE AUTHORS, Continued



LT. (jg) KENNETH B. PLATT, M.S., was Regional Range Examiner, Oregon Region, U. S. Grazing Service, Burns, Oregon, when he was inducted into the Navy in March 1944. He was born at Forest, Idaho, in 1907 and grew up in the ranch livestock industry. His B.S. in agriculture (animal husbandry) was obtained from the University of Idaho where he was active in debating, cross country, and ROTC rifle team and edited the agricultural college annual. He took his M.S. at the University of Minnesota and then returned to the University of Idaho as assistant in animal husbandry. After writing popular bulletins on livestock feeding, he became assistant in extension in charge of the farm and home radio program with side duties in agricultural newswriting and editing. In 1936 Mr. Platt joined the U. S. Grazing Service. In 1939 he was appointed Superintendent of the Squaw Butte-Harvey Range and Livestock Station, a range grazing laboratory in Eastern Oregon. His boot training in the Navy began in March 1944. In May he was assigned for training in the naval quartermaster school at Farragut, Idaho. In August he was commissioned Lt. (jg) and sent to Tucson, Arizona, for indoctrination. In November he was assigned to a military government training school at Princeton University. In 1945 he was sent to the office of the Port Director, Pearl Harbor.

CAPT. MYRON W. CURZON, MBA, LL.B., is a member of the General Staff Corps, AUS. Unfortunately, we have little information about him. His master's degree was taken at the University of Chicago in 1936 and his law degree from Indiana University in 1942. He was drafted in 1942 and after attending Officer Candidate School was commissioned in 1943. He has served in the headquarters Office of the Director of Military Training and in the Special Planning Division, War Department Special Staff.

NEW BOOKS, Continued

No sane person would want a war to happen so that unusual case histories might be recorded. But, when wars do occur, every opportunity should be used to investigate the human fragments it scatters to learn more about its effects. *War Neuroses* (Blakiston, $2.75) is such an attempt by two army medical officers who served in the Tunisian campaign. For a long time it was kept in a confidential classification by the military authorities and is now released for a wider distribution. The book was prepared under the stress and pressure of conditions in a theater of military operations so that medical officers in other theaters could quickly profit by the experiences of the Tunisian battle. The principal sections deal with: Clinical syndromes; Psychiatric problems in the Air Forces; Etiology; Prognosis: Treatment and results; and Psychobiologic dynamics.

In the world of astronomy, the announcement of a book by Bart J. and Priscilla F. Bok, of Harvard, is always an event. In 1941 these two stargazers published *The Milky Way* (Blakiston, $2.50), and on our desk we now have the second edition. We are not surprised that this member of the Harvard Books on Astronomy has entered the ranks of those books that meet with such success that a new edition becomes necessary. The authors have availed themselves of the opportunity to bring the book up to date and there are new chapters discussing spectral glasses, the nearest stars, cosmic dust and the interstellar gas, the structure of the galaxy, and the cosmic time scale.

Nearly every scientist at one time or another in his career is attached to an academic institution and during that period finds himself serving on committees concerned with matters relating to curricula, course content, graduate students, and a host of other common college problems. The day comes, too, for most of them, when the matter of selection of an institution for the education of their offspring presents itself. In all of these deliberations an attempt is made to make comparisons with the offerings of many institutions. The problem of making accurate comparisons is not easy and so it was with real interest that we went through *A Guide to Colleges, Universities, and Professional Schools in the United States* just issued by the American Council on Education ($5.00). We can recommend this report for several uses: First, to every person who is called upon in some capacity to advise with returning veterans; and second, to all officers and teachers who are interested in the availability of comparable figures on the cost of attending various colleges and universities.

Our last new book of the month is *Systematic Politics* by that veteran of the political arena, Dr. Charles E. Merriam (University of Chicago Press, $3.75). We feel perfectly easy about referring to Dr. Merriam as a political veteran, for his career has not been limited to academic habitation. He played a major role in Chicago politics—than which there is none more rugged—as alderman for six years, candidate for mayor, and chairman of the Chicago Commission on City Expenditure. Because of his practical experience Dr. Merriam knows his politics. And now a word about his latest of many books. He looks at government as a cross-section of the cultural pattern of the society in which it exists, with external order, justice, general welfare, and freedom as its ends. He has distilled for us from his studies and experiences an analysis of how far we have progressed in political action and how much farther we might advance in the light of what we now know.

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Founding and Organization

In 1848, on September 20, the Association was formally organized and held its first meeting; in 1874 it was incorporated under the laws of the Commonwealth of Massachusetts and given the right to receive, purchase, hold and convey property. Its governing body is a Council, now having 255 members.

The Association is national in scope, with membership open to the whole world on equal terms, and its interests include the broad fields of the natural and the social sciences. Its varied activities are carried on under 16 sections with which 190 affiliated and associated societies, having a combined membership of nearly a million, cooperate in organizing programs for its meetings.

Members and Meetings

All persons engaged in scientific work, all who find pleasure in following scientific discoveries, all who believe that through the natural and social sciences a better society may be achieved are eligible for membership in the Association. From its founding, the most distinguished of American scientists, including every American Nobel Laureate in science and every president of the National Academy of Sciences, have been members. The names of many university presidents, of eminent scholars in widely different fields, and of men notable for public service, including a United States Senator, a Justice of the Supreme Court, and a former president of the United States, are now on its roll of more than 27,000 members.

The Association's meetings are field days of science attended by thousands of participants at which hundreds of scientists vie with one another for the pleasure and the honor of presenting results of researches of the greatest benefit to their fellow men. An enlightened daily press reports their proceedings throughout the country.

Opportunity and Responsibility

A world torn by conflicts and fearful of the future is looking more and more toward scientists for leadership. The opportunity for unparalleled service is theirs and the fact that they have available the only essentially new methods, if not purposes, imposes an equal responsibility. For these reasons it will be the Association's steadfast purpose to promote closer relations among the natural and the social scientists, and between all scientists and other persons with similar aspirations, to the end that they together may discover means of attaining an orderliness in human relations comparable to that which they find in the natural world about them.

MEET THE AUTHORS

L. L. THURSTONE, M.E., Ph.D., is the Charles F. Grey Distinguished Service Professor of Psychology at the University of Chicago, where he has served in the Department of Psychology since 1924. He was born in Chicago in 1887. After graduation from Cornell University in 1912, he served for a short time as an assistant to Thomas Edison. He does not tell us how he became a psychologist, but in 1915 at the Carnegie Institute of Technology he began his career of teaching and research in psychology. He took his Ph.D., presumably in psychology, at the University of Chicago in 1917. He remained in Pittsburgh until 1923 when he went to Washington to serve for a year as Psychologist with the Institute for Government Research. Dr. Thurstone is skilled in statistical methods, so necessary for progress in his research on mental abilities. That his results are highly regarded is indicated by his election to membership in the National Academy of Sciences.

LLOYD W. TAYLOR, Ph.D., is Professor and Head of the Department of Physics in Oberlin College. He was born in Pittsfield, Me., in 1893, graduated from Grinnell College in 1914, and took his Ph.D. from the University of Chicago in 1922. Before he went to Oberlin in 1924, he taught in Grinnell College and the University of Chicago and had two years of extracurricular activities in the Army of the United States during World War I. Dr. Taylor is the author of four books and the senior co-author of a fifth. He was president of the American Association of Physics Teachers (1943–44). Until preoccupation with problems of World War II put a stop to nonessential activities of physicists, he indulged in two hobbies: genealogy and English bell ringing [*sic*]. His principal professional interest is the adaptation of physics to the liberal arts curriculum. We hope that he will interpret developments in physics for the SM.

NEW BOOKS

> Each age, it is found, must write its own books; or rather, each generation for the next succeeding. The books of an older period will not fit this.

When Emerson wrote the above words as part of his famous address "The American Scholar," given at the Harvard commencement in 1837, he was thinking largely of books in the realm of philosophy. And yet in the address there are many indications that he was not oblivious to the importance of books in the various departments of the sciences. Certainly the thought as he expressed it is as genuine today as it was over a century ago. Books are the silent partners of every scientist, waiting to be used at every turn and opportunity.

It is because of the importance of books that the A. A. A. S. has always featured the Science Library at its science exhibition held in conjunction with its annual meetings. Two months hence, in St. Louis, the Association will hold its first large general meeting since the end of the war. Books are destined to play an even larger part in the science exhibition than ever before. On another page in this issue, a complete announcement of the Science Library will be found. The members of the Association's staff charged with primary responsibility for this feature have been working long and hard at the problem of assembling a comprehensive exhibition of books. One of the greatest difficulties has been that of getting together a group of books representing the work of our foreign colleagues during the war years. Many of the legations and embassies have been helping us, and, if all goes well in the next two months, those who attend the meetings will be able to see what scientists abroad were able to do in spite of the war.

Last week your book review editor had an opportunity to spend several days in New York and while there to visit several of the publishers whose primary work is related to scientific publishing. All the publishers have plans for increased numbers of new books, when and as more paper becomes available. Two other bottlenecks were frequently mentioned: the difficulty of getting material released from military security regulations and then getting the authors to submit the manuscripts.

To our way of thinking the month's outstanding book is *Men Without Guns* by DeWitt Mackenzie (Blakiston, $5.00). This is a full-dress

NEW BOOKS, Continued

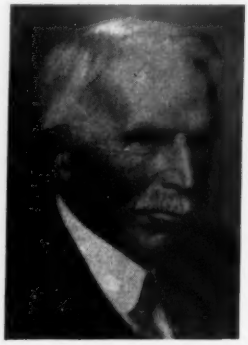
report of those unsung heroes of any war, the army medical folks. Theirs is a heartbreaking task, performed by flashlight, candle, or gas lamp on a distant shore. After the first assault wave has gone up, their work begins in earnest as the stretcher-bearers start to bring back the twisted, broken wrecks that once were human beings. Somewhere, far away, someone is waiting for each casualty to return and in spirit must be standing at the side of each nurse and doctor as they work swiftly to repair the damage that man has done to man. Mackenzie's report is documented by 118 full-color plates of original paintings commissioned from famous artists. The paintings catch the stark reality and futility of war with an eeriness that cannot be caught with photographs. We put the book down with the feeling that a League of Nations or a UNO would not be necessary if each of us could serve as men without guns.

The Smithsonian Institution has sheltered the Association for more years than we can recall, and this year it celebrates its centennial. There will be many ways to salute this world-renowned organization during the present year, but we can think of no better way than to call attention to its *Annual Report, 1944* (Government Printing Office, $1.50) which has just come from the press. In its quiet, unobstrusive way the report focuses attention on the wide range of activities that are administered from the offices clustered under and around the Brownstone Tower on the Mall. Little did James Smithson, its founding patron, realize the tremendous job of integrating science and the arts this institution would achieve within the space of one hundred years. The report is truly *the* science book of the year and deserves to be read by everyone.

1945 was also the occasion of a double anniversary in the scientific world. On March 27, 1845, Wilhelm Conrad Röntgen was born in Lennep, Germany. Fifty years later on November 8, 1895, Röntgen gave the world its first information on what we now know as X rays. It would be next to impossible to catalogue the new fields and advances that this discovery opened to all scientists. In commemoration of Röntgen's contribution several scientific bodies have jointly sponsored a biography *Wilhelm Conrad Röntgen* written by Otto Glasser (Charles C. Thomas, $4.50).

This month's mail brought us two other biographical works. From Macmillan came the

MEET THE AUTHORS, Continued



O. F. Cook, Ph.B., hon. Sc.D., is a distinguished botanist, officially retired from the U. S. Department of Agriculture but still active at the age of 78 in botanical pursuits. A native of New York State, he graduated in 1890 from Syracuse University, which honored him forty years later by conferring upon him the degree of Doctor of Science. Like David Fairchild, Dr. Cook has had a life of botanical adventure in many parts of the world. Soon after graduation and up to 1897 he spent most of his time in Liberia teaching, collecting plants and animals, and studying colonization of Negroes in that republic. From 1898 until his retirement he was a plant scientist of the USDA, rising to the rank of Principal Botanist. Space is lacking to list the many expeditions of which he was a member. He specialized on cotton and rubber plants, as well as on the classification of palms. Still enthusiastic, Dr. Cook comes down to the Smithsonian once a week from his home in Lanham, Md., to study plants in the National Herbarium.

S. Chandrasekhar, Ph.D., is an unofficial representative and interpreter of India to the United States. At the time he submitted information about himself he was a Lecturer on Indian economic and social problems in the Department of Oriental Studies at the University of Pennsylvania. Dr. Chandrasekhar was born in southern India in 1918 and graduated with honors from the Madras Presidency College. He took his master's degree at Columbia and his doctorate at New York University in economics and sociology. His primary interest is in population problems, the subject of his book *India's Hungry Millions*. He travels extensively in the United States lecturing on India's political and economic problems. Recently he returned to India, and is now back again in New York City where he can be addressed at 55 Morton St.

MEET THE AUTHORS, Continued

WARD SHEPARD, A.B., M.F., was born in Ohio fifty-eight years ago, graduated from Harvard College in 1910 and from the Harvard Forest School in 1913. He has had wide experience in the conservation of natural resources, especially in the social engineering aspects of scientific land management. He has held various posts in the Departments of Agriculture and Interior, and from 1936 to 1939 was Director of the Harvard Forest and a member of the faculty of the Harvard Graduate School of Business Administration. He has served in the Office of Indian Affairs as adviser on Indian self-government and land management and is one of the founders of the newly created Institute of Ethnic Affairs, to promote more effective research-action programs in the field of interracial relations. His *Food or Famine: The Challenge of Erosion* was recently published by Macmillan. Mr. Shepard popped into the Brownstone Tower just when we wanted to consult him about his manuscript. His office is in the Department of the Interior and his home at Vienna, Va., on R.F.D. 2.

MARTIN K. BARNETT, M.S., is finishing his wartime work as research engineer at Battelle Memorial Institute, Columbus, Ohio, preparatory to taking a new position. A gentleman from Indiana, born in 1909, he did his undergraduate work at Butler University, specializing in chemistry and mathematics. He took his master's degree at the University of Cincinnati where he developed his interest in the history of the concepts and laws of classical thermodynamics. Six years as research chemist and metallurgist for the National Malleable and Steel Castings Company preceded his appointment at Battelle. Mr. Barnett also dropped in to see us recently to tell us that he will soon be living in Washington. Like many other scientists, he is deeply interested in statistical methods.

The most important scientific books of the past year will be shown at the

SCIENCE LIBRARY

Of the 113th A. A. A. S. Meeting

St. Louis, March 27-30

At each meeting of the A. A. A. S. the leading scientific publishers combine to present their foremost publications of the preceding year in the Science Library. In addition many of the companies have their own individual exhibits with additional books on display.

This year, the Science Library will have an unusually large and outstanding collection of fine books. In many instances, material recently released from military security regulations will be available for the first time. Extra space has been allotted to the Science Library so that there will be adequate facilities for leisurely inspection and reading of the many books on display.

As in past years, the March issue of *The Scientific Monthly* will carry a listing of all books submitted for deposit in the Science Library up to the time the issue goes to press. And at the meeting a reprint of the listings, together with important announcements by the publishers and other exhibitors, will be distributed free.

Trained librarians will be in attendance at the Science Library at all times and will assist those who wish to order books from the various publishers.

Visit the Science Library at the meeting. It is arranged for your enjoyment and inspection by the cooperating publishers.

NEW BOOKS, Continued

Life and Work of John Tyndall written by A. S. Eve and C. H. Creasey. It had been Tyndall's intention to publish an autobiography written jointly with his wife with the title *Our Autobiography*. As is so frequently the case with busy scientists, his work was paramount and his own written interpretation of results was set aside as "future work." It would be difficult to find a person in recent scientific history who was so talented in both pure scientific research and its interpretation for the masses. Fortunately Tyndall's scientific habits carried over into his personal affairs, and he left a most complete record of all of his activities. The great mass of material has been successfully winnowed by the two biographers and the true stature of Tyndall allowed to be fully seen.

For many months we have thought of saying a word about a phase of the publishing business that we find fascinating. This month four books arrived—books that give us a peg on which to hang a comment or two about the university presses and the regional publishing houses. In some instances the university presses started out as purely regional publishers and then went on to become national and international publishers; for example, the University of Chicago Press and Harvard University Press. Others continue to devote their efforts to books about their immediately surrounding territory. These regional publishing houses are distinctive ventures, too. Usually they are started by a person or a group with an intense devotion to a particular region and its contribution to the development of the nation. In many cases these publishers are not motivated by profit-making desires, and through the years may have to be subsidized by interested wealthy patrons. This month we made the acquaintance of a new regional publisher, Glade House, and, as one would guess from the name and its attractive colophon cut, it specializes in books about the Southeastern United States, particularly Florida. Glade House has published recently *Living by the Land* by John C. Gifford ($2.50) and *Fontaneda's Memoir* edited by David O. True ($2.00). Dr. Gifford's book is concerned with conservation, chiefly conservation of the natural resources of Florida and the surrounding region. Dr. Gifford has earned the right to tell us about conservation because his entire life has been devoted to this cause. At the very beginning of the book he states his thesis: conservation does not mean merely saving and hoarding; it means, rather, *sane use*. And from that point on, by specific example and well-chosen photographs, he drives home the need for continuous conservation.

Fontaneda's Memoir is a new appraisal of the translation by Buckingham Smith published in Washington in 1854. Fontaneda was a Spaniard who was shipwrecked on the Keys and captured by the prehistoric Indians of South Florida, the Caloosas. He was the first white man to see the Everglades and to live with those early Indians, who have so completely disappeared. Fontaneda escaped and returned to Spain, where he wrote this *Memoir*, which could be rightly called one of the first accurate travel books about America.

Uneasy Money (University of Oklahoma Press, $1.50) is Edward H. Faulkner's latest book. Faulkner is famous for his preceding book, *Plowman's Folly* published by the same press. In this new book, Faulkner tries his hand at solving the ever-present problem of balancing industrial and agricultural production so as to achieve a balanced national and international economy. One of the most difficult tasks that he sees before agriculture is the problem of maintaining present production levels, but with lower costs. To the farmer, his statement that farming methods must be upgraded considerably may seem wishful thinking. To the industrial employees in large cities, his advice to start raising part of their own food may seem desirable but far from attainable. Perhaps Faulkner's ideas are right, and it is only their newness that makes their acceptance seem distant.

Age brings with it encrusting dignity and a desire for respectability. Many businesses and professions that have progressed from lusty (and in some cases illegal) beginnings do not wish to be reminded of their origins. Top-notch advertising executives are always deploring the reference to their field as the "advertising game." But there is one group of Americans who take pride in the activities of their predecessors, and, though they may use more modern methods, the elements of adventure, risk, and danger still are potent. A new book from the Princeton University Press, *The Wildcatters*, tells the history of oil-hunting in America. We thought as we read the book of the contribution of the wildcatters in the form of Paul Bunyan tales, colorful additions to the language, and help in opening up new regions. To our minds, *The Wildcatters* is on a par with *Shepherd's Empire* published by the same press late last year.

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Concisely, we are delighted to report that we are constantly adding to our list of valuable publications and will continue to enlarge our ability to serve front-line scientists.

Faithfully,

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MEET THE AUTHORS

Harris & Ewing

VANNEVAR BUSH, D.Eng., Sc.D., LL.D., is known to every scientist as Director of the wartime Office of Scientific Research and Development. Had not the responsibilities of this position prevented him from serving as President of the A.A.A.S., he might now be the subject, instead of the author, of our leading article. Dr. Bush and President Conant were our leading scientific statesmen of World War II. It is our hope that next year President Conant will write our leading article about Dr. Bush. We shall therefore not attempt to describe his wartime achievements but will merely outline his previous career. Dr. Bush was born at Everett, Mass., in 1890. He took his B.S. and M.S. degrees at Tufts College and pursued advanced graduate work in electrical engineering at Harvard and M.I.T., both of which institutions awarded him the D.Eng. degree in 1916. After World War I, during which he worked on submarine detection, he returned to M.I.T. as associate professor of electric power transmission. He was advanced to professor in 1923, and in 1932 he became vice-president of the Institute and Dean of its school of engineering. In 1938 he was elected president of the Carnegie Institution of Washington, D. C., a position that he still holds. In 1940 President Roosevelt appointed Dr. Bush chairman of the National Defense Research Committee. A year later he was made Director of OSRD, comprising NDRC and the newly formed Committee on Medical Research. Like Dr. Kettering, Dr. Bush is noted for his inventions, which have been focused on the application of mechanical and electronic means to reduce the burden of computation, calculation, and repetitive work. The most important result of his inventive genius is M.I.T.'s differential analyzer, a complex electrical machine designed to provide solutions of differential equations. The record shows that Dr. Bush has received eight medals and eleven honorary degrees. He is a member of the National Academy of Sciences. Of course he is in demand as a trustee of educational and scientific institutions. Altogether, his abilities as an engineer and executive have been thoroughly utilized and appreciated by science and government.

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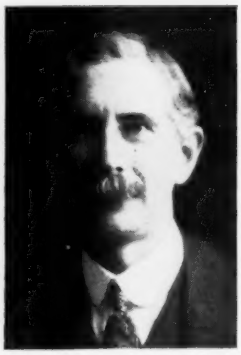

CHARLES GREELEY ABBOT, Sc.D., LL.D., recently retired as Secretary of the Smithsonian Institution, now occupies the top floor of the Brownstone Tower and is occupied by his astrophysical research, which at the age of seventy-three he pursues with the persistence and enthusiasm of a young man about to take his Ph.D. Dr. Abbot was born at Wilton, N. H., in the house shown below, where he grew up. He received his formal education at Phillips Andover Academy and at M.I.T. where he specialized in physics. Since he took his master's degree in 1895, he has been associated with the Smithsonian Institution, first as assistant in the solar researches of the Astrophysical Observatory, then in 1906 as its director, a position he held for almost forty years. In addition, he was appointed Assistant Secretary of the Smithsonian Institution in 1918 and was elected Secretary in 1928. Upon his retirement in 1944 he was appointed Research Associate. His notable accomplishments in the field of solar radiation are outlined in his present article "The Sun Makes the Weather." Dr. Abbot is the author of several books and many scientific papers. From 1918 to 1923 he served as Home Secretary of the National Academy of Sciences. He never let paper work prevent him from participating personally in the research of the Astrophysical Observatory and even now, if he is not in his office, he may be found in the machine shop, making his own instruments. Except for an occasional round of golf, Dr. Abbot makes work his recreation.

MEET THE AUTHORS, Continued

BANCROFT H. BROWN, Ph.D., has been Professor of Mathematics at Dartmouth College since 1931. He was born at Hyde Park, Mass., in 1894. After graduating from Brown University, he spent two years in the Army and took his doctorate at Harvard in 1922. Ever since, he has taught mathematics at Dartmouth. In recent years Professor Brown has been interested in the purely numerical aspects of applied mathematics and has developed analyses and summaries in widely varied fields such as games, gambling, chronology, eclipses, cartography, and meteorology. His present article on "The Scoring of Athletic Contests" is an example of his professional hobby, which we hope will lead to additional articles for the SM. A mathematical article on gambling should be salutary.

TOM BURNS HABER, Ph.D., is an instructor in English at The Ohio State University. A native of Ohio, born at Rossburg in 1900, he was educated at Ohio Northern University and Ohio State, taking his doctorate at the latter institution in 1929. He also studied abroad during three summers: Oxford; Munich; Paris and Berne. Dr. Haber has specialized in language and comparative literature, his dissertation being *A Comparative Study of Beowulf and the Aeneid*. He is co-author of *A Grammar of Living English* and author of *Writer's Handbook of American Usage* and *Handbook of Basic English*. We should like to know what our readers think of his arguments for the use of Basic English in scientific writing. Dr. Haber has numerous professional and nonprofessional interests off the campus. He is now president of the Columbus Chapter of the English-Speaking Union and of the Columbus Rose Club. His roses have won many trophies and ribbons, and he is a contributor to *The American Rose Magazine*. Also interested in archery, he writes for *The American Bowman*.

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MEET THE AUTHORS, Continued

ALDEN H. MILLER, Ph.D., is Professor of Zoology at the University of California, Berkeley, and Director of the Museum of Vertebrate Zoology. Born in Los Angeles in 1906, he did his undergraduate and graduate work at the University of California where he remained in teaching and research. In addition to his studies of the speciation and adaptation of birds, he is a constant student of bird behavior and has carried on field work in the western United States, British Columbia, Central America, and northern South America. With the late Joseph Grinnell he has written *The Distribution of the Birds of California.* His work on speciation in the avian genus *Junco* received the Brewster Medal of the American Ornithologists' Union. Since 1939 he has been the editor of *Condor.*

WILLIAM T. SKILLING is a retired professor of astronomy whose hobby is science writing. In the February 1944 SM he wrote on the source of the heat of the sun and stars, a subject that he has brought up to date in the present issue by showing the relation between release of energy from the sun and that from the atomic bomb.

KARL P. SCHMIDT is not only Chief Curator of Zoology at the Chicago Natural History Museum but is one of the SM's dependable poets and idea men. (See the November 1944 SM for further information about this versatile naturalist.)

JAMES G. NEEDHAM, formerly head of the Department of Entomology at Cornell University, finishes in this issue one of the most fascinating stories of scientific life and work that we have had the privilege of publishing in the SM. He is now wintering, but not hibernating, at Sarasota, Fla.

JOEL W. HEDGPETH, free-lance writer and marine biologist, was introduced in the November 1944 SM (The Passing of the Salmon). Since then, in addition to his present sonnet, he has contributed two articles to the SM. He is now employed by the Game, Fish and Oyster Commission, Rockport, Tex.

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NEW BOOKS

In these days of strenuous efforts to solve the manifold problems of the minorities within our borders, we frequently forget that as a nation we have overseas minorities who are our wards and direct responsibility. These minorities, no less than those who live with us and have daily contact with us, have problems that need careful consideration. The book which so deeply impressed this fact upon us is *The Aleut Language* by Richard H. Geoghegan (Government Printing Office, 1944). Written characters for the Aleut sounds were first introduced into the several islands of the Aleutian chain by a Russian missionary, Ivan Veniaminov, in 1825. When the United States acquired Alaska from Russia in 1867, the Aleuts automatically exchanged their status as subjects of the Russian Czar for American citizenship. The delay in relating the Aleut language more closely to the speech of their present countrymen has kept the Aleuts emotionally linked to a dead Russian past for three-quarters of a century and has hindered their development as American citizens. Dr. Geoghegan died before the final work on this dictionary could be completed, and Fredericka I. Martin undertook the arduous task of editing it. Lest anyone be inclined to shrug off works of this kind with a scant "so what?" let us remember the strategic value of Alaska in an air-minded world that thinks of traveling between American cities and Asiatic centers by the great circle route, and that our northern territories lie in the heart of such projects. The day may soon come when the United States will need the help of its fellow-citizens to the Far North. Certainly for these reasons and as the champion of freedom for minorities we cannot lightly dismiss our responsibilities to the Aleuts.

Three books were received this month that will be of interest to the biomedical folks: *Nutrition and Chemical Growth in Childhood* (Charles C. Thomas, $10.00); *Biological Actions of Sex Hormones* (Cambridge University Press, $8.50); and *Contributions to Embryology* (Carnegie Institution of Washington, $4.50 paper, $5.00 cloth). *Nutrition and Chemical Growth in Childhood* is the second volume of a work written by Icie G. Macy, Director of the Research Laboratory, Children's Fund of Michigan. In it are gathered all of the original data that formed the basis of Volume I published under the same title. It was the purpose of the studies to obtain the greatest possible amount of accurate information about the growth and development of a few normal children under conditions comparable to those of a healthy home environment. Some idea of the large scope of the project can be found in the statement that "in the course of the studies over 6,000 five-day balances were determined, approximately 18,000 analytical values for intake, urine, and feces." Other phases of the study involved observations of the utilization of food substances under several abnormal conditions, and original work on the metabolism of normal children. The entire volume is a gold mine of basic and accurate data that will yield "pay dirt" for researchers in this field for years to come.

SM readers working with radio should know about *Radio Test Instruments* by Rufus P. Turner (Ziff-Davis, $4.50) and *Two-way Radio* by Samuel Freedman (Ziff-Davis, $5.00). Both books are primarily for the radio engineer. The first book should prove useful for the engineer who must train semiskilled personnel in the use of testing equipment. The language is simple and nonmathematical and the diagram of wiring adequate. The subject of two-way radio opens up many interesting possibilities, some of which have already been exploited by the cartoonists showing Mr. Scientist getting instructions for shopping from Mrs. Scientist as he is en route home. The book deals extensively with problems of equipment, theoretical aspects of broadcasting and reception, and potential uses for two-way equipment.

Insect Dietary by Charles T. Brues (Harvard University Press, $5.00) brings together the diverse relations of insects to their environment through the medium of their food, discusses the devious ways in which they have exploited the living world in their search for food, and shows how these activities have guided their evolution and affected that of many other animals and plants. The first chapter deals with the vast extent and varied characteristics of the insect world, and the second, "Types of Food Habits," is a prelude to the more specific and detailed accounts of special adaptations outlined in subsequent chapters. In the final chapter Professor Brues presents interesting data on the utilization of insects as food by man and other organisms. "Insects," says Professor Brues, "have filled the open spaces and swarmed into every nook and cranny on our earth, discovering food of a kind everywhere. . . ." Briefly; any natural organic material, living or dead, may be food for insects.

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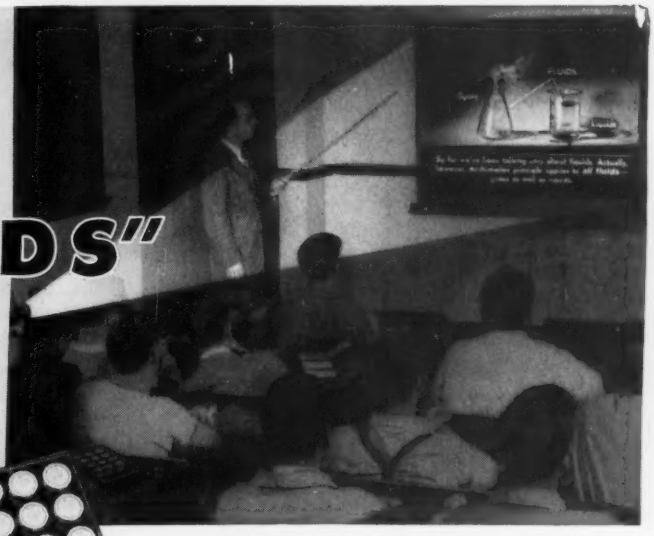

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MEET THE AUTHORS

E. V. Cowdry, Ph.D., is Professor of Anatomy at Washington University and Director of Research of the Barnard Free Skin and Cancer Hospital, St. Louis. Born at Fort MacLeod, Alberta, Canada, July 18, 1888, he was educated in Canada, England, Switzerland, and the United States. He has served on the staff of the University of Chicago, the Johns Hopkins Medical School, the Peking Union Medical College, and the Rockefeller Institute for Medical Research. For him distant fields have always been attractive, and he has studied malaria in Tunis, east coast fever in Kenya Colony, heartwater in the Transvaal, leprosy in Puerto Rico, and medical education in many parts of Japan and China. Trained as a cytologist, under the inspiring leadership of Professor R. R. Bensley, of the University of Chicago, he realizes that the cancer plague is a cellular problem. His paper in this issue is based on lectures given before a joint session of the Society of Sigma Xi and the Detroit Physiological Society and at Wheaton College. It is presented in the hope that it will aid in the national campaign of the American Cancer Society to raise funds to combat this disease.

George P. Meade, Ch.E., is manager of the Colonial Sugars Company's refinery at Gramercy, La., a subsidiary of the Cuban-American Sugar Company. Born in Cumberland, Md., in December 1883, he graduated in chemical engineering at New York University in 1905. His sugar career started in summer work the year before he entered college, and since then he has worked for the same group of companies in Eastern Seaboard refineries, Puerto Rico, Cuba, and Louisiana. He is the author of the 8th edition of the Spencer-Meade *Cane Sugar Handbook*, published in 1945 and now in its 55th year. Translations of this work have appeared in Spanish and Japanese. Mr. Meade's extensive backyard collection of

NEW BOOKS

Anthropologists everywhere and particularly those whose main interest lies in the Pacific area will be interested in Volume IV of the *Yale Anthropological Studies*, "Bibliography of Indonesian Peoples and Cultures" ($2.50), and in *Peoples of Malaysia*, by Fay-Cooper Cole, of the University of Chicago (D. Van Nostrand Company, Inc., $4.00). Raymond Kennedy is the compiler of the Yale bibliography, which has eight main divisions: Indonesia (general), Sumatra, Java, Borneo, Celebes, the Lesser Sundas, the Moluccas, and Netherlands New Guinea. Cole's book is based on his many years of research on the area and field trips for first-hand observation. After two chapters devoted to a general historical review, he takes up the Pygmies, the Sakai, the Malay of the peninsula, and the Philippines, Borneo, Bali, Java, Sumatra, and Nias. There are three appendices that will be useful to the beginning student of anthropology: Tribal Maps; Physical Types and Relationships; and Distribution Chart of Cultural Traits Among Test Groups.

The United States National Museum has released two bulletins summarizing part of its continuing research on biological life in Siam. Bulletin 186 is *The Birds of Northern Thailand* (Government Printing Office, $1.25), and Bulletin 188 is *The Fresh-Water Fishes of Siam, or Thailand* (Government Printing Office, $1.50). Each of these bulletins will add to the already considerable reputation of the Museum for careful and complete listings of native species. Both of them may be seen by ornithologists and ichthyologists in The Science Library at St. Louis.

The Commonwealth Fund has just published *Medicine in Industry*, by Bernhard J. Stern ($1.50), an excellent addition to the growing list of "Studies of the New York Academy of Medicine Committee on Medicine and the Changing Order." It presents a balanced picture of environmental factors that have bred new—or at least hitherto unknown—diseases and have modified or increased the incidence of old ones. Attention is also paid to special emotional and mental conditions attributable to the monotony of many of the techniques and operations in modern industry and to intensified antagonisms between employer and employee. Stern surveys past accomplishments and offers practical suggestions for solving some of the perplexing problems of this branch of medicine. In the Preface Paul Reznikoff asks: What

NEW BOOKS, Continued

should be the role of the physician in industrial medicine? Should he be a specialist who devotes his time exclusively to the prevention and treatment of accidents and industrial disease, leaving to the worker's family physician illness not definitely of industrial origin?

In *Marine Microbiology* (Chronica Botanica, G. E. Stechert and Company, New York, $5.00) Claude E. ZoBell, of the Scripps Institution of Oceanography, has summarized and correlated the extensive literature on the subject of hydrobiology, with particular reference to the importance of bacteria and allied microorganisms as biochemical, geological, and hydrobiological agents. The chief emphasis is on sea organisms, but frequent observations were made in inland bodies of water, owing to the possibility that there may be common elements in the evolutionary development of kindred types. The discussion of the practical aspects of microbiology, such as the collection and analysis of water and mud samples, will be of value. The bibliographical sections do not contain comprehensive listings, but serve rather as a directive to stimulate students to further study. A useful author index follows the bibliography.

Chauncey D. Leake, well known to readers of THE SCIENTIFIC MONTHLY as the exponent of "Ethicogenesis," has written an introductory essay for Thomas E. Keys's *History of Surgical Anesthesia* (Schumans, $6.00). In the chronology of events we find *c.* 2250 B.C. Nippur:

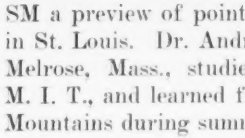
> Babylonian clay tablet reveals remedy for pain of dental caries. Cement was made by mixing henbane with gum mastic.

There are sections by the author on "The Development of Anesthesia," "A Chronology of Events relating to Anesthesiology and Allied Subjects," a chapter by Noel A. Gillespie on "The Future of Anesthesia," and selected references by subject. Keys's book is a fascinating study and makes almost as exciting and stimulating reading as a good mystery story.

Academic Press has just sent out copies of the first issue of the long-awaited *Journal of Colloid Science*. The intention of the publishers to establish and maintain an international character for this *Journal* is indicated by contributions from Hungary, England, and the United States. Victor K. LaMer, of Columbia University, is Editor-in-Chief.—T. J. C.

MEET THE AUTHORS, Continued

reptiles has made it possible for him to publish a dozen or more articles on the life history and breeding habits of the harmless snakes of Louisiana and has led to his membership in several societies devoted to herpetology. He is also interested in athletic records and in 1916 he published an article in the SM on mathematical aspects of track records. Under his sponsorship several Southern A.A.U. championship swimming teams have been developed at Gramercy, and because of this interest he has been a member of the men's swimming committee of the National A.A.U. for many years. A public-spirited citizen, Mr. Meade serves also as president of the St. James Parish (County) School Board, chairman of the St. James-Ascension Boy Scout District, and chairman of the Re-employment Committee of the St. James Selective Service Board.



HENRY N. ANDREWS, Ph.D., like Dr. Cowdry, holds two positions in St. Louis. He is Associate Professor of Botany at Washington University and Paleobotanist and Assistant to the Director of the Missouri Botanical Garden. It was Dr. Andrews who gave the readers of the March SM a preview of points of interest to scientists in St. Louis. Dr. Andrews was born in 1910 in Melrose, Mass., studied industrial biology at M. I. T., and learned from nature in the White Mountains during summer vacations. His graduate work was done principally at Washington University (St. Louis) where he received his Ph.D. in 1939. In 1938–39 he devoted himself to paleobotanical studies at Cambridge University, England, and, before returning, he collected specimens in the coal fields of Belgium and worked for a few weeks in the museums of Paris and Stockholm. His present research deals with certain Cretaceous deposits of Wyoming and Idaho and the fossil plants of the Illinois coal fields. He is proud to be the scientific godfather of Jules Kernen, the winner of the Fifth Annual Science Talent Search. Of Kernen he writes: "He is indeed a remarkable boy. We are collaborating in a technical paper that will appear in the next issue of the Garden *Annals*. It is a feat that I never would have thought possible for a boy of high school age."

MEET THE AUTHORS, Continued

HARVEY N. DAVIS, Ph.D., Sc.D., D.Eng., LL.D., has been President of Stevens Institute of Technology since 1928. He was born in Providence, R. I., June 6, 1881, and grew up on the campus of Brown University, where his father was Professor of Mathematics. After graduating from Brown he took his advanced degrees at Brown and Harvard. Until he was called to Stevens, he served on the Harvard faculty, becoming Professor of Mechanical Engineering in 1919. During World War I he was engaged in investigations on production of helium and during the recent war he served as Director of the Office of Production Research and Development of the War Production Board. Of the three requisites for engineering—money, materials, and men—President Davis emphasizes men and is a believer in a more liberal education for engineers than they customarily receive. He would place specialized engineering training in graduate schools.

CAPT. ERNEST CHERRINGTON, JR., Ph.D., is a staff officer in the Research and Development Division, Headquarters of the Army Service Forces. Born in 1909 at Westerville, Ohio, he received A.B. and M.S. degrees from Ohio Wesleyan University and completed his graduate studies at the University of California. He was then appointed Morrison postdoctorate research fellow in the Lick Observatory but resigned to accept a teaching position in Syracuse University. For six years prior to his entry into the Army Air Forces in 1942 he carried on astronomical research in the Perkins Observatory and taught on the faculties of Ohio Wesleyan and Ohio State Universities. Specializing in spectrophotometric investigations of Be stars, he discovered the startling increase in luminosity of Gamma Cassiopeiae. He also discovered emission lines in the spectra of several other bright stars. His first three years in the Army were devoted to supervising the training of some 10,000 combat pilots. He served as Director of Ground Training at Merced Army Air Field (basic flying school), at Mather Field (B–25 advanced school), and at Hobbs Army Air Field (B–17 transition school). His staff of some 75 instructors taught navigation, meteorology, engineering, and other technical subjects. His hobby is popularizing science, in the pursuit of which he has lectured extensively and has published numerous articles in leading periodicals.

MEET THE AUTHORS, Continued

ARCHIE J. BAHM, Associate Professor of Philosophy and Sociology, Texas Technological College, can be "met" in the May 1944 SM, in which we published his "Teleological Arguments." As regional secretary of the American Humanist Association he is qualified to discuss Humanism in his present essay.

ARAM BOYAJIAN is a cultured electrical engineer, whose first contribution to the SM (December 1944) was an exposition of Kant's philosophy by means of an imaginary dialogue between the great philosopher and a great experimental scientist, A. A. Michelson. In his present essay on the Ego, Id, and Superego Mr. Boyajian delves into psychology. If any professional psychologists or psychiatrists are horrified by his interpretation of their findings, let them come forward with contributions as clear and interesting as A. B.'s.

THOMSON KING is another engineer who is not a stranger to the humanities. He is employed by the Consolidated Gas, Electric Light and Power Company of Baltimore. Poetry (see his sonnet on page 334) is one of his hobbies; atomic physics, astronomy, and fossils also receive his attention. He is president of the local Shakespearean Society.

ALEXANDER F. SKUTCH, American naturalist living on his farm in Costa Rica, now presents his third essay since we published his "Parable for Peacemakers" and his brief autobiography in the April 1944 SM. We have yet to hear any reader say, "Too much Skutch."

CLARENCE R. WYLIE, JR., is delineated in the December 1945 SM. So far we have published four of his poems, including the present "Lines for a Very Young Scholar." His contributions will not be limited to verse, however, for we have accepted his manuscript entitled "Mathematical Allusions in Poe."

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MEET THE AUTHORS

WALTER W. RISTOW, Ph.D., is associated with the Map division of the New York Public Library. He was born in La Crosse, Wis., in 1908 and majored in geography at the University of Wisconsin. He continued his studies in geography at Oberlin College and Clark University with intervals of teaching his subject at Berea College and the Eastern Washington College of Education. When he received his Ph.D. from Clark in 1937 he joined the staff of the New York Public Library. From 1942 to 1944 he served as head of the Geography and Map Section of the New York Office of Military Intelligence. Dr. Ristow had a happy thought when he turned his interest in maps to a study of automobile road maps for the SM. There is sweet nostalgia in his story for those who, as boys, could identify every automobile on the road and dreamed of the day when they might drive a Stutz or a Marmon.

JEROME ALEXANDER, M.Sc., is an eminent consulting chemist and chemical engineer with an office and laboratory at the Chemists' Club in New York City. A true New Yorker, he was born in the big city almost seventy years ago and was educated at the College of the City of New York. Until 1921 he was employed as treasurer and chief chemist of certain companies; then he established his own consulting business. Mr. Alexander is regarded as an authority on colloid chemistry, a difficult branch of chemistry that extends from physical chemistry to biology and has important technological and medical significance. Mr. Alexander has followed the ramifications of colloid chemistry into many other fields, becoming in the process one of chemistry's great scholars. His broad interests are exemplified by his present article on catalysts, which ranges from 100-octane gasoline to cancer. His own book *Colloid Chemistry* reached its fourth edi-

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MEET THE AUTHORS, Continued

tion in 1937, and he is the editor of, and contributor to, six large volumes on *Colloid Chemistry, Theoretical and Applied,* containing contributions from about 350 scientists from many nations. Mr. Alexander is also known as the poet of chemistry. Collections of some of his verse have appeared as *Essences from Life's Alembic* and *Retorts from a Chemist's Laboratory.*

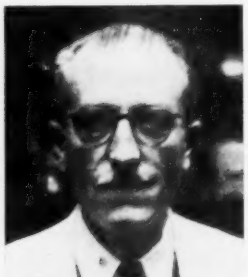
JOHN M. HUTZEL, Ph.D., became Administrative Assistant of the American Association for the Advancement of Science after his separation from the Navy late last year. He now shares the "Dungeon" with Dr. F. R. Moulton. He was born in Benton Harbor, Mich., in 1916 and grew up in Detroit and Ann Arbor where he graduated from the University of Michigan. In the course of his graduate research at the Ohio State University he developed a chalklike stick of sodium fluoride for roach control and studied quantitatively the initial paralytic effect of pyrethrum on roaches. Before entering the Navy in 1943 as a malariologist Dr. Hutzel served for a year as instructor in insecticides at O.S.U. and worked on rotenone insecticides for the Bureau of Entomology and Plant Quarantine. In the Navy he was attached to the malaria and epidemic control unit of the Fourth Marine Division. He was exposed to the hazards of invasion of the Marshall Islands and Iwo Jima and thus prepared himself for the hazards of the St. Louis meetings, for the arrangements of which he was largely responsible. His part in the planning and execution of airplane spraying for insect control on Iwo Jima is described in his present article.

MAJOR THOMAS A. HART, Ph.D., was a counterpart of Lt. Hutzel in the Army. He is now engaged in mosquito control in Bolivia. He came into the office one day with his manuscript on malaria control in New Guinea and wanted us to publish it in order to give the boys in malaria survey and control more recognition for their achievements than they had hitherto received. Unfortunately I failed to record Major Hart's life history before he went to South America. I remember that he took his Ph.D. at the University of Chicago under Professor C. G. Huff

MEET THE AUTHORS, Continued

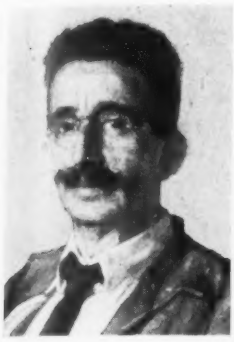
in malariology and thus was well qualified to be among the first officers to undertake malaria control in New Guinea. We have only a small snapshot of Major Hart showing him standing beside one of the "educational" signs which were painted in the jungle to urge soldiers to protect themselves against malaria. An oriental potentate is being entertained by a sinuous dancer; the sign is captioned, "Atabrine Keeps Me Going."

ARTHUR C. GIESE, Ph.D., Associate Professor of Biology at Stanford University, was born in Chicago in 1904. He attended the University of Chicago where he received his B.S., did graduate work at the University of California and Stanford University, and received his Ph.D. at the latter institution in 1933. He spent 1939–40 on a Rockefeller Fellowship at Princeton University and at the Marine Biological Laboratory at Woods Hole, Mass. At Stanford and at the Hopkins Marine Station he teaches invertebrate biology, general and comparative physiology, and photobiology. His research has included studies on the effects of ultraviolet light upon cellular processes, cellular nutrition and respiration, and bioluminescence. He does not explain how he happened to collaborate with Mr. Wells (see the following sketch) on a study of sunburn.

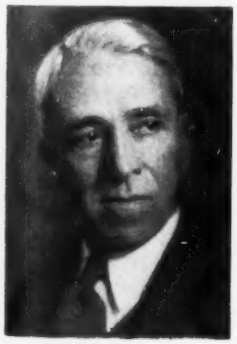


JULIAN M. WELLS, B.A., Instructor in Pharmacy and Supervisor of the Dispensing Laboratory and Lecturer in Pharmacology in the Medical School, was born in Gordon, Neb., in 1902. He attended the University of California where he received his B.A. in 1930. He did graduate work at the University of Washington in 1940. Since 1930 he has been teaching at the University of California. His research interests have been on pharmaceutical problems, especially vehicles for ointment and other external preparations, as well as buffered and isotonic vehicles.

MEET THE AUTHORS, Continued



FREDERICK S. HAMMETT, Ph.D., is a physiological chemist and is Scientific Director of the Lankenau Hospital Research Institute of Philadelphia, Pa., and North Truro, Mass. He lives in Provincetown on the tip of Cape Cod. Born in Chelsea, Mass., in 1885, he was an undergraduate at Tufts and a graduate student at Rhode Island State College and Harvard where he received his Ph.D. in 1915. Then followed a few years of teaching. In 1919 Dr. Hammett went to the Wistar Institute in Philadelphia and eight years later he began his present work which has been centered around the chemistry of growth in relation to cancer. His dissatisfaction with the performance of some of his laboratory assistants gave rise to his present article in which he calls for a broader preparation of graduate students for research. Dr. Hammett is an editor of *Growth*, of which he was the instigator. He regularly attends the Saturday night revels of the local Beachcombers, of which he is a member. The above likeness is a photograph of his portrait signed "To Doc Hammett—Miller."



J. D. Tolott, F.R.P.S.

OLIVER JUSTIN LEE, Ph.D., is chairman of the Department of Astronomy and Director of the Dearborn Observatory in Northwestern University. He was born in Minnesota in 1881. His undergraduate work at the University of Minnesota led him to undertake research in astronomy at Yerkes Observatory and to obtain advanced degrees at the University of Chicago. He remained on the teaching staff at Chicago for thirteen years. In 1929 he took his present position. Rather massive research programs have characterized Dr. Lee's career. They have included radial velocities of stars, parallaxes and proper motions of stars, distance to the sun by observations of Eros, a longitudinal campaign, and spectrographic survey of the faint red stars in the Northern Hemisphere. He has been a member of several astronomical expeditions and served the nation during World War I as the director of the U. S. Shipping Board's school of navigation in Chicago. Dr. Lee's philosophic curiosity and sense of responsibility caused him to take the lead in searching for unifying elements in our experience with nature and society. His present description of Northwestern's pursuit of the unities in higher education may be a partial solution of the problem posed by Dr. Hammett.

MEET THE AUTHORS, Continued

Signal Corps Photo

MAJOR J. HAROLD BYERS, LL.B., is Chief of the Evaluation Section, Patent Branch of the Legal Division, Office of the Chief of Ordnance. His duties involve study of proposals of allegedly new inventions, evaluation with reference to military utility, novelty, and patentability, investigation of claims of infringement, determination of questions of validity, and supervision of negotiations for settlement. The military life is not strange to him for he writes: "I narrowly escaped being born on an island military reservation called Fort Warren, off the coast of Massachusetts. It was decided instead that I should be inducted at Chambersburg, Pa., my mother's home. This was in 1900. Thereafter we rejoined my father at his station and for the next fifteen years lived in a state of incipient transfer from post to post." From 1920 to 1927 Major Byers was engaged in research with the Optical Glass Section of the U. S. Bureau of Standards. His patent work began in 1927, and his civilian occupation is that of Patent Examiner in the U. S. Patent Office, specializing on applications for patent in the chemical arts, mainly oils, fats, waxes, soaps, and lubricating compositions. Being a reserve officer, he was ordered to active duty shortly after Pearl Harbor. He does not state when he will return to the Patent Office. We suspect that he must be an unusually competent Examiner, for his present article on criteria of patentability is distinguished by its clarity.

A CORRECTION: *Shepherd's Empire* (New Books, THE SCIENTIFIC MONTHLY, February 1946) is a publication of the University of Oklahoma Press, not of Princeton University Press.

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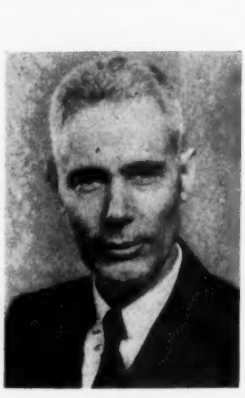
MEET THE AUTHORS, Continued

CARL F. WEHRWEIN, Ph.D., is Chief of the Food Programs Division, Office of Foreign Liquidation Commissioner, State Department. He was born at Manitowoc, Wis., in 1893 and received his B.S. from the University of Wisconsin. He engaged in several non-academic activities before returning for graduate work to the University of Wisconsin where he received his Ph.D. in 1930. Then followed ten years as a member of the faculty of the same institution, his work having been research in land economics and public finance. In 1940 Dr. Wehrwein joined the Bureau of Agricultural Economics, U.S.D.A., to supervise the economic phases of flood survey work in watersheds west of the Continental Divide. With the discontinuance of the flood survey program in the fall of 1941, Dr. Wehrwein joined the Washington staff of the War Production Board and served three years as senior industrial analyst. He transferred to the Foreign Economic Administration in November 1944 and when that agency was broken up in October 1945 he moved with its Food Programs Division to the State Department.



WALTER H. PIELEMEIER, Ph.D., is Professor of Physics in The Pennsylvania State College. He was born near Vincennes, Ind., in 1889. He did part of his undergraduate and all of his graduate work at the University of Michigan, where he served as instructor in physics before he came to Penn State in 1920. His research has been concerned with supersonics and the absorption and velocity of high-frequency sound. He became interested in sounds produced by insects through work on a war project and also by inspiration from his neighbor and colleague, Professor S. W. Frost, who is an entomologist.

FOR SUTER, VISHER, and GLICKSBERG see 1944 SM (April, May, and July respectively).

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Founding and Organization

In 1848, on September 20, the Association was formally organized and held its first meeting; in 1874 it was incorporated under the laws of the Commonwealth of Massachusetts and given the right to receive, purchase, hold and convey property. Its governing body is a Council, now having 255 members.

The Association is national in scope, with membership open to the whole world on equal terms, and its interests include the broad fields of the natural and the social sciences. Its varied activities are carried on under 16 sections with which 196 affiliated and associated societies, having a combined membership of nearly a million, cooperate in organizing programs for its meetings.

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All persons engaged in scientific work, all who find pleasure in following scientific discoveries, all who believe that through the natural and social sciences a better society may be achieved are eligible for membership in the Association. From its founding, the most distinguished of American scientists, including every American Nobel Laureate in science and every president of the National Academy of Sciences, have been members. The names of many university presidents, of eminent scholars in widely different fields, and of men notable for public service, including a United States Senator, a Justice of the Supreme Court, and a former president of the United States, are now on its roll of more than 27,000 members.

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A world torn by conflicts and fearful of the future is looking more and more toward scientists for leadership. The opportunity for unparalleled service is theirs and the fact that they have available the only essentially new methods, if not purposes, imposes an equal responsibility. For these reasons it will be the Association's steadfast purpose to promote closer relations among the natural and the social scientists, and between all scientists and other persons with similar aspirations, to the end that they together may discover means of attaining an orderliness in human relations comparable to that which they find in the natural world about them.

MEET THE AUTHORS

RALPH W. GERARD, Ph.D., is Professor of Physiology at The University of Chicago. He was born at Harvey, Ill., in 1900 and received his B.S. from The University of Chicago in 1919 and his Ph.D. two years later. Following his graduation from Rush Medical College and his internship he spent two years in study and research in London and Berlin. A distinguished neurophysiologist, he has done extensive research on the way in which nerves and the brain function, investigating the chemical constitution and change of the nerves and brain during activity, growth, and injury. He pioneered in the study of the effect of blood sugar on the brain and has investigated sleep and dreaming by means of brain waves. Dr. Gerard was one of the founders of the American Association of Scientific Workers, an organization of scientists which has undertaken both the interpretation of science and the creation among scientists of an awareness of the social consequences of their work. He was president of the Chicago branch of the Association last year. He has also found time to write books and numerous scientific articles and to serve as an editor of various biological reviews and journals. Prior to October 1945, he spent three years in government research on the physiological effects of phosgene.

MELVIN RADER, Ph.D., is Associate Professor of Philosophy at the University of Washington. Born in 1903 at Walla Walla, Wash., he has lived most of his life in that state. He received the Ph.D. in English at the University of Washington and began his teaching career at Western Reserve University, Cleveland. Within a year he had decided to transfer to philosophy, in which he had for some time been interested. Since 1930 he has been teaching it. Dr. Rader's principal interested in social philosophy. He has published two books, *No Compromise* and *A Modern Book of Esthetics*, and has contributed to other books.

MEET THE AUTHORS, Continued

ROBERT B. DOWNS, M.S., is Director of Libraries at the University of Illinois. He was born in 1903 at Lenoir, N. C., and received his A.B. at the University of North Carolina and his B.S. and M.S. at Columbia. He entered the library profession at an early age, starting when he was nineteen as a student assistant in the University of North Carolina Library and continuing without a break to the present time. In the course of his career he has headed four libraries: Colby College, University of North Carolina, New York University, and, since 1943, the University of Illinois Library and Library School, plus two years with the New York Public Library. He has long been interested in problems of library resources. In addition to numerous articles relating to the subject, he has written or edited volumes on the resources of New York City and Southern libraries, American library facilities for war purposes, union catalogs in the United States, and library specialization. Mr. and Mrs. Downs collect examples of American humor.

LOREN C. EISELEY, Ph.D., is Professor and Head of the Department of Sociology in Oberlin College. He was born in Lincoln, Neb., in 1907. He took his A.B. at the University of Nebraska and his Ph.D. at the University of Pennsylvania, in 1937, where he was Harrison Fellow in Anthropology. Before coming to Oberlin in 1944 he taught anthropology and sociology at the University of Kansas. Dr. Eiseley has published extensively on paleontological and archeological problems involving the subject of Early Man in North America. He has served on a number of expeditions, both paleontological and archeological, in the Great Plains area and in the Southwest. His interests range from scientific research to literature. Moult's *Best Poems of 1942* carries one of his sonnets, and he is listed on O'Brien's "Honor Roll of the American Short Story" for 1936.

MEET THE AUTHORS, Continued

T. L. SWENSON, Ph.D. (Chemistry), is Director of the Western Regional Research Laboratory, Bureau of Agricultural and Industrial Chemistry, USDA, Albany, Cal. A resident of the State of Washington from 1906 to 1929, he held many positions in that state as pharmacist, clinical technician, and chemist. In 1929 he was appointed to the USDA and has since conducted research investigations on the molding of shell eggs during storage, on enzyme action at low controlled temperatures, and on various methods of quick freezing of poultry, and has published numerous papers as a result. Dr. Swenson successfully developed and patented a new method for the manufacture of dried egg white, by which drying time was cut from five or six days to forty-eight hours. He also developed and perfected an enzymic method for the recovery of egg foam which forms in heavy masses during the fermentation of egg white, and collaborated in the development of the patented process for the prevention of "freezer-burn" and loss of bloom in the quick freezing of poultry. His interest in research relating to industrial utilization of agricultural products is therefore of long standing.

RALPH COGHLAN is editor of the editorial page of the St. Louis Post-Dispatch, a newspaper which represents to many intelligent people better American journalism than most. Mr. Coghlan responded to a request for his life history in these words: "An informal biography? Of course you know the history of man as compounded from the wisdom of the ages by Anatole France: 'Man is born, he suffers, and he dies.' I haven't died yet, but have toiled over a hot typewriter in the office of the *Post-Dispatch* for some twenty years. For fourteen years I have been an editorial writer and for the remainder of the time editor of the editorial page. Before that I spent my salad days on Marse Henry Watterson's *Courier-Journal* and the *Louisville Post*. I have seen the world grow progressively worse—and now comes the atom bomb. Well, there is still hope if the men of science enter the field of politics and help give direction to our wavering statesmanship." Mr. Coghlan is a real Middle-Westerner, born at Chicago in 1896 and educated at John Marshall Law School and the University of Wisconsin.

MEET THE AUTHORS, Continued

THOMAS DARLINGTON COPE, Ph.D., was born sixty-five years ago at Cope's Bridge on the Brandywine in Chester County, Pa. Five miles westward from his birthplace lies the Mason and Dixon country. He has heard its story all his life. Eight years ago the Pennsylvania Academy of Science visited the Stargazers's Stone on Harlan's Farm. Then and there Dr. Cope was "put on the spot" to account for all the tradition that hangs over the place. To answer questions he has gone to the records and has published seven articles; more are in prospect. The American Philosophical Society held at Philadelphia for Promoting Useful Knowledge has just made a generous grant in support of the project. Dr. Cope is Professor of Physics at the University of Pennsylvania where he has taught for forty years.

HAROLD LEWIS COOK is a graduate of Union College, Schenectady, N. Y., and has been a teacher of English Literature for many years in this country and in France. Since 1941, however, he has been engaged in quite a different kind of work: training nearly 8,000 war workers in technical and supervisory problems in the factory of a leading manufacturer of aircraft ignition. He has published many poems.

READ BAIN is Professor of Sociology at Miami University. He has written us a long and extremely interesting letter telling us what he thinks of poetry, the SM, Reader's Digest, and science in general. He says: "I am thoroughly convinced that the poetry of the future will be based on science just as the poetry of the past was based upon the animistic longings and phantasies of the prescientific age." Therefore, "greatly shocked by the animistic sentimental tone of Hedgpeth's 'Possibility,'" he "had to write 'Improbability.'"

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Man's Food

Its Rhyme or Reason

by Mark Graubard

About the Book

The story of food is a fascinating episode in the drama of human evolution. Food is the basis of life and health; but is also the crossroads of emotion, religion and tradition.

This volume differs from most books on the subject in its extensive treatment of man's past and present attitudes toward food. Its chapters on the foods we eat and require contain historical surveys of their origin and role in society, welfare, and the beliefs which man lives by. After a description of the dietary notions and practices of the past, man's food is analyzed in the light of the young and vigorous science of nutrition.

The change from superstition to science in man's dietary conduct leads the author to some novel and interesting comments on human nature. To this he adds brief surveys of the role of food in wartime, the value of a nutrition movement in improving food habits and a discussion of the means whereby science and democratic organization may achieve freedom from want in food.

About the Author

Dr. Graubard has done research in biochemistry and has published works on the food habits of primitive man and on human biology. He was on the staff of Columbia and Clark Universities and lectured widely. During the war he was in charge of labor education in the office of nutrition, U. S. Department of Agriculture and at the present time he is associated with the Library of Congress.

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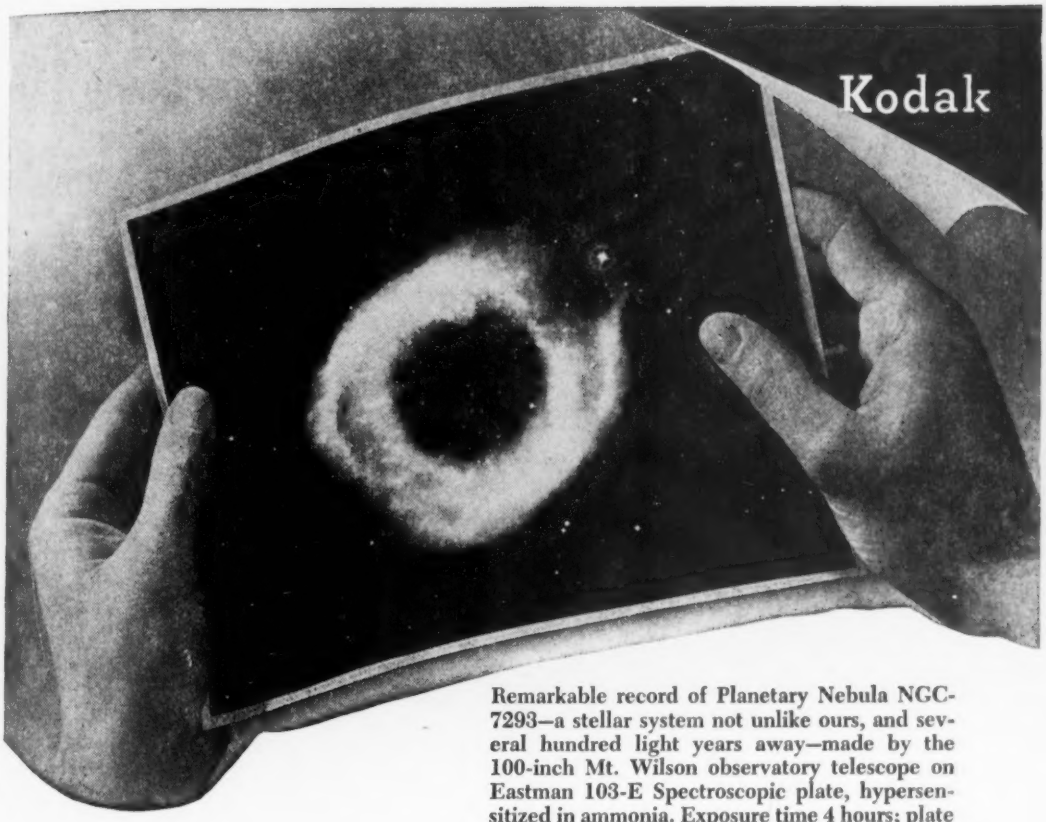

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